NORFOLK HARBOR, VA.

CRANEY ISLAND DISPOSAL AREA

GENERAL DESIGN MEMORANDUM

SUBMITTED 24 MARCH 1953

REVISED 10 NOVEMBER 1953

CORPS OF ENGINEERS
U. S. ARMY
NORFOLK DISTRICT

CORPS OF ENGINEERS, U. S. ARMY
Office of the Division Engineer
North Atlantic Division
New York 7, N. Y.

NADGW

31 July 1953

SUBJECT: Definite Project Report - Norfolk Harbor, Va. - Craney Island Disposal Area

TO: The Chief of Engineers,
Department of the Army,
Washington 25, D. C.

ATTENTION: ENGWE

1. In accordance with discussion of the subject project with Col. Milne 30 July 1953 in this office, there are inclosed a draft of the report together with comments of this office and related data for your advance consideration.

2. It was agreed that the District would study the comments and be prepared to discuss them in about 2 weeks at a conference to be held in your office for the purpose of arriving at a firm evaluation of the project economics prior to submission of the FY 55 budget.

3. A conference date of 17 August 1953 is suggested.

FOR THE ACTING DIVISION ENGINEER:

WILLIAM C. READY
Colonel, CE
Asst. Division Engineer

3 Incl
1. cy 1st Ind, NAD to NAC, 31 Jul w/5 incl
2. cy memo fm Chief Appraiser NAO, 10 Jul (dup)
3. cy ltr NAD to NAP, dtd 17 Mar 53 w/1st ind thereto dtd 5 May 53

ENGWE

SUBJECT: Definite Project Report - Norfolk Harbor, Va. - Craney Island Disposal Area (Ltr NAD to OCE 31 Jul 53)

1st Ind

Office of the Chief of Engineers, Washington 25, D. C., 12 August 1953

TO: The Division Engineer, North Atlantic Division, Corps of Engineers, NEW YORK, NEW YORK

1. A review of the data submitted indicates that no worthwhile purpose would be served by a conference in the immediate future and, accordingly, the proposed conference will be deferred indefinitely.

2. It is the view of this office that the alternative plans briefly discussed and roughly evaluated by the Division Engineer do not accomplish some of the important objectives of the project document plan. Since some of these objectives have been fundamental considerations in dealings with local interests over a number of years and in representations made to Congress for authorization purposes, it does not appear proper at this juncture to sacrifice them on the sole grounds of possible, but not certain, economies of government plant operation. Accordingly, it is concluded that fundamental changes in the project document plan need not be considered further.

3. The Division Engineer should study thoroughly all possible ways of achieving economy in Craney Island disposal area operation. The most fruitful field for study appears to lie in the rehandling facilities.

4. Comments on details of the plan are as follows:

a. Riprap on outer face can be reduced to 24-inch thickness due to flat slope of hydraulic fill, which will break waves before they reach riprap.

b. Riprap on inner surface should be reduced to 12 inches, as area is shallow and will become more so as use is made of area for disposal.

c. Settlement plates should be omitted unless they are to be used for determining payment yardage.

d. More space between the roadway decks at the spillways would be desirable to facilitate handling of flash boards.

5. Subject to the above comments and the applicable comments of the Division Engineer, the draft of the Definite Project Report is approved.

ENGWE

SUBJECT: Definite Project Report - Norfolk Harbor, Va. - Craney Island Disposal Area (Ltr NAD to OCE 31 Jul 53)

1st Ind (Cont'd)

6. After the further studies are completed, the design memorandum should be submitted for final approval.

BY COMMAND OF MAJOR GENERAL STURGIS:

Incls w/d

WM. WHIPPLE
Colonel, Corps of Engineers
Executive
Civil Works

NADGW (31 Jul 53) 2nd Ind
SUBJECT: Definite Project Report - Norfolk Harbor, Va. - Craney Island Disposal Area

Office, Division Engineer, North Atlantic Division, Corps of Engineers, U. S. Army, New York 7, N. Y., 18 August 1953

TO: The District Engineer, Norfolk District, Corps of Engineers, U. S. Army, Norfolk 1, Va.

Forwarded for your information and appropriate action.

BY ORDER OF THE DIVISION ENGINEER:

WILLIAM C. READY
Colonel, CE
Asst Division Engineer

NAOGS 827.41(Nfk Hbr) 3d Ind
(31 July 53)
SUBJECT: Definite Project Report - Norfolk Harbor, Va. - Craney Island Disposal Area

Norfolk District, Corps of Engineers, U. S. Army, Norfolk 1, Va., 10 Nov 53

TO: Division Engineer, North Atlantic Division, Corps of Engineers, U. S. Army, New York 7, N. Y.

1. In compliance with pars 4, 5 and 6 of 1st Indorsement, the design memorandum has been revised and is submitted herewith for approval.

2. As required in par 4214.12 of O&R, 3 sets of full size drawings, and 12 extra copies of the basic letter and indorsements are also furnished.

3. Twelve copies of Appendix I7 - Lands - were submitted separately by letter, NAOVR, Norfolk District to Division Engineer, NAD, 9 Nov 53, subject: "Real Estate Memorandum, Norfolk Harbor, Va., Craney Island Disposal Area." Copies of letter of 28 Aug 53 from the Attorney General of Virginia stating that the reservations in the deed to the Government dated 19 June 48 were not intended to, and are not construed as imposing a reversionary provision in the conveyance were submitted with the above letter and are also inclosed herewith for convenience.

FOR THE DISTRICT ENGINEER:

3 Incls.
1 -3 w/d
Added 3 Incl --4 - 6
4. Gen Design Memo w/copy of basic ltr & indorsements (12 cys) (Under s/c)
5. Full size dwgs (3 sets) (Under s/c)
6. Cy ltr Atty Gen of Va. 28 Aug 53 (in quad)

C. J. ROBIN
Chief, Engineering Division

C O N T E N T S

LIST OF TABLES

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PERTINENT DATA

Location of Site

In Craney Island Flats adjacent to and immediately north of Craney Island and west of the westerly limit of the Norfolk Harbor 40-foot Channel in Hampton Roads, Va.

Area of Disposal Area

Area inclosed by levees	2,500 acres

Capacity of Disposal Area

Ultimate capacity	96,000,000 cu. yds.

Life of Disposal Area

Estimated life based on annual deposit of 4,300,000 cu. yds. of material as compiled from dredging records 1932 to 1952 and estimated maintenance dredging for projects now in report stage and normal expansion of naval facilities	22 years

Elevation, Feet Referred to Mean Low Water as 0.0 Datum

Crown of levees	+8.0
Top of revetment	+8.0
Toe of revetment	-1.0
Sluiceway flashboards	+2.0 to +7.0
Pipeline trestle	+8.0
Range structures	+14.0
Rehandling basins	-40.0

Levees

Type - hydraulic sand fill with stone revetment
Foundation - varies from soft marine clay to firm sand

Length	30,830 feet
Elevation	+8.0 feet
Maximum width at base	840 feet

Revetment

Type	Stone
Thickness	
Outside slope	2.75 feet
Inside slope	1.5 feet
Top elevation	+8.0 feet
Toe elevation	-1.0 feet

Pipeline Trestle

Type - treated pile and timber structure

Length	2,500 feet
Elevation of pipe	+8.0 feet
Foundation	Marine clay
Pile penetration	50-60 feet

Rehandling Basins

Number	2
Bottom elevation	-40 feet
Length	800 feet
Width	200 feet

Approach - approach area provided to Norfolk Harbor 40-foot channel

Sluiceways

Type - treated pile and timber structures

Number - The disposal area will be divided into three areas by levees constructed during rehandling operations. One sluiceway is provided for each of these areas. . . . 3

Elevation of flashboards	+2.0 to +7.0 feet
Length	64 feet
Width	22 feet
Foundation	Piles
Pile penetration	50-60 feet

Access Road

Length	3,500 L.F.
Width of paved surface	18 feet
Maximum grade	1.5 per cent
Elevation of crown	+8.0 to +18.0 feet

Construction Quantities (approximate)

Hydraulic dredging (excavation)	790,000 cu. yds.
Hydraulic sand fill	7,670,000 cu. yds.
Embankment (borrow)	123,000 cu. yds.
Excavation (common)	4,500 cu. yds.
Nominal 1000-lb. stone	87,200 tons
Nominal 200-lb. stone	40,000 tons
Crushed rock	58,900 tons
Treated piling	59,180 L.F.
Crushed stone surfacing	82,400 sq. yds.
Treated structural timbers	143.43 MBM
Galvanized hardware	21,440 lbs.
Purchase of land	38.2 acres
Purchase of leased oyster grounds	87.7 acres

Estimated Costs (Based on December 1952 Price Levels)

Retaining levees	$ 4,837,900
Sluiceways	88,500
Pipeline trestle	193,700
Range markers	26,000
Rehandling basins and access area	155,800
Land and oyster bottom	98,000
Access road	28,400
Rehandling plant	2,394,500
Navigation aids (U. S. Coast Guard)	11,000
Preparation of design memorandum and plans and specifications	178,200
Total estimated Federal cost of project	$ 8,012,000
Total non-Federal cost	-0-
Total estimated cost of project	$ 8,012,000

Estimated average annual cost of operation and maintenance of disposal area and rehandling plant subsequent to completion of the project . . . . . $ 1,235,600

SYLLABUS

1. The Craney Island Disposal Area was authorized by the River and Harbor Act approved 24 July 1946 (Public Law 525, 79th Congress, 2nd Session).

2. The definite project plan contemplates a disposal area, with retaining levees, two rehandling basins and other rehandling facilities, adjacent to and north of Craney Island in Norfolk Harbor. The area would cover approximately 2,500 acres and would be adequate for the disposal of at least 96,000,000 cubic yards over an estimated 22 years. Dredged material would be transported to the rehandling basins by scows or hopper dredge and dumped. From these basins the dumped material would be moved by a hydraulic dredge through fixed and movable pipeline to the disposal area. The retaining levee would be hydraulically constructed of sand fill and would be protected by stone revetment on both sides. The sluiceways and pipeline trestle would be of treated pile and timber construction. Rehandling operations would be by means of a hydraulic dredge of suitable capacity.

3. It is estimated that the total cost of the authorized project would be $8,012,000, including construction, land and acquisition costs, damages to leased oyster bottom, rehandling plant, engineering, supervision, overhead, and contingencies. Approximately 2-1/2 years would be required for the construction of the project. A toll charge per cubic yard for rehandling material into the disposal area would be assessed against all users of the project except the Corps of Engineers.

4. Local interests have indicated that they will cooperate fully and there have been no indications of local opposition to the project. All requirements of local cooperation set forth in the project document have been fully met by local interests, in this case the Commonwealth of Virginia, except for permanent termination of unexpired oyster leases. Prior to initiation of work, it is proposed for the Federal Government and State to jointly negotiate with the lessees for voluntary termination of these leases, the Government's obligation being limited to merely the crop damage and the State's obligation as to damage, if any, for the unexpired term of the leases. In the event voluntary termination negotiations are not successful, condemnation proceedings will be initiated with both State and Federal Government participating as their interests may appear. The above exception is in addition to the payment of toll charges to be assessed actual users of the area.

5. The Navy Department will interpose no objections to establishing the disposal area to the north of Craney Island, provided the Navy's interests are amply protected, and the present drainage of Craney Island is maintained to protect adjoining Navy property when the fill in the area progresses shoreward.

A. PROJECT AUTHORIZATION

1. Authority. Authority for the construction of a disposal area for dredged material adjacent to and north of Craney Island, Norfolk Harbor, Va., including the necessary appurtenances and facilities, is contained in the River and Harbor Act approved 24 July 1946 (Public Law 525, 79th Congress, 2nd Session), which reads in part as follows:

> "That the following works of improvement of rivers, harbors, and other waterways are hereby adopted and authorized to be prosecuted under the direction of the Secretary of War and supervision of the Chief of Engineers, in accordance with the plans and subject to the conditions recommended by the Chief of Engineers in the respective reports hereinafter designated: . . . .
>
> "Norfolk Harbor, Virginia; House Document Numbered 563, Seventy-ninth Congress"

2. Authority for the preparation of this report is contained in paragraph 4214.01, Orders and Regulations, Corps of Engineers. The initial allotment of funds was made to Division Engineer, NAD, 7 Nov 47, subject: "Advance Planning - Definite Project Report, Norfolk Harbor, Va., Craney Island Disposal Area."

B. INVESTIGATIONS

3. Project document. The approved general plan of the project is outlined in a report, together with accompanying papers and illustrations, referred to as a Review of Reports on Norfolk Harbor, Va., published as House Document No. 563, 79th Congress, 2nd Session.

4. Engineering investigations for the project document included subsurface investigations; hydrographic and topographic surveys of the levee site and the adjacent shore area; studies of alternative plans; gross appraisals of land values; and estimates of benefits and costs of the recommended plan. The subsurface investigations consisted of thirty disturbed drive borings taken within the limits of and adjacent to the proposed disposal area to determine the character of bottom material preparatory to the design of retaining structures, and for the purpose of locating sufficient deposits of sand for construction of the retaining levees.

5. General design memorandum. In connection with the preparation of this report, additional subsurface investigations were made, consisting of 11 undisturbed drive borings and 72 disturbed drive borings. Laboratory analyses were conducted to determine the character and properties of the foundation material and stability of the slopes of the proposed levee. Detailed field investigations were made in connection with studies of access roads, power supply, railroad facilities, drainage of upland adjacent to the site of the disposal area, and real estate to be acquired. A gross appraisal of waterfront property to be acquired was made by experienced land appraisers.

6. Soil analyses and levee designs, estimates of cost of levees, revetment, spillways, and pipeline trestle, and gross appraisals of the upland and building values of adjacent waterfront property were also made. The laboratory tests and analyses of the levee foundation materials were conducted by the Ohio River Division Laboratories.

7. Departures from project document. There are no significant departures from the project document. The economic analysis of the general plan takes into account the general increase in cost of construction. The more detailed designs, plans, and soil analyses that were made in connection with the preparation of the design memorandum gave due consideration to the modifications of the levee design as recommended by the Board of Engineers for Rivers and Harbors.

8. Public hearing. On 1 August 1944, a public hearing was held at Norfolk, Virginia, by the District Engineer and was attended by representatives of the State of Virginia, the Fifth Naval District, Norfolk & Western Railway Company, Seaboard Air Line Railroad Company, Southern Railway System, Chesapeake & Ohio Railway Company, Virginian Railway Company, Newport News Shipbuilding & Dry Dock Company, Hampton Roads Maritime Exchange, sea-food interests, and terminal operators. Since the above-names interests, and other local interests not represented at the hearing, had no specific plan to offer regarding the problem of providing for long-term disposal of dredged material, the proceedings were confined largely to the discussion of the merits of a tentative disposal plan conceived by the District Engineer. As evidenced by testimony at the hearing, local interests strongly endorsed the disposal plan presented by the District Engineer. No subsequent hearing has been held although letters from interested parties since the project was authorized indicate a desire for early construction of the project.

C. LOCAL COOPERATION

9. Requirements. The requirements of local cooperation as set forth in House Document No. 563, 79th Congress, 2nd Session, are:

"Users of the disposal facilities, other than the Engineer Department, shall pay to the district engineer a fixed unit toll for such use, including the cost of rehandling dredged material into the disposal area, the amount of such toll to be determined by the Chief of Engineers and to include interest on and amortization of the net investment and operation and maintenance costs;

"The Commonwealth of Virginia will --

Convey to the United States, by appropriate legislation or otherwise, title to the submerged lands permanently occupied by the disposal area and terminate all existing oyster leases in effect within the limits of the disposal area; it being understood that the United States will compensate private oyster growers for crops in production on the submerged lands at the time of occupancy by the United States;

Terminate, prior to the initiation of the construction and for the useful life of the disposal area, the leases of private oyster growers for leaseholds in areas on the south side of Hampton Roads which may be necessary for the construction, maintenance, and operation of the disposal area, including dredging for fill material adjacent to the disposal area; it being understood that at the time of the termination the United States will compensate these oyster growers for crops in production;

Except as provided above, release the United States from all claims for such damages as may occur to public or leased oyster bottoms from the construction, maintenance, and operation of the project."

10. Commonwealth of Virginia. In compliance with local cooperation requirements set forth in the project document, the State of Virginia has conveyed by deed, dated 19 June 1948, without cost to the United States, all right, title and interest in the submerged land to be occupied by the disposal area. The conveyance is expressly made subject to the rights of lessees of such oyster planting grounds as may be included in the lands conveyed and subject to the provision that the United States shall compensate, at the time of its occupancy, all oyster growers for crops in production, who hold leases from the State of Virginia in the submerged lands conveyed, or any other submerged lands on the south side of Hampton Roads which may be necessary for the construction, operation and maintenance of the project, including dredging for fill material adjacent to the disposal area. The latter provision is in accordance with project document requirements. An opinion has been received from the Attorney General of the State of Virginia, dated 28 August 1953, clarifying the provision in the aforesaid deed pertaining to "jurisdictional limitations and reservations." The effect of this opinion is to show that there are no reversionary title conditions attached to said deed.

11. The General Assembly of Virginia has also enacted legislation (House Bill No. 381) releasing the United States from all claims for damages as may occur to public or leased oyster beds from the construction, operation and maintenance of the project excepting that the United States shall compensate, at the time of its occupancy, all oyster growers for crops in production who hold leases from the State of Virginia in the submerged lands above described or any other submerged lands on the south side of Hampton Roads which may be necessary for the construction, operation and maintenance of the project, including dredging for fill material adjacent to the disposal area. The latter exception is in accordance with project document requirements.

12. In view of the fact that leases executed by the State of Virginia to private oyster growers are for a term of twenty years each and have no cancellation provisions, and also the fact that there is no statutory authority in Virginia for the State to revoke or cancel these leases, the State of Virginia would have to exercise its power of eminent domain to effect an involuntary termination of the leases of private oyster growers for leaseholds in the disposal area or on the

south side of Hampton Roads. Prior to initiation of work it is proposed for the Government and State to jointly negotiate with the lessees for voluntary termination of these leases; the Government's obligation being limited to merely the crop damage and the State's obligation as to damage, if any, for the unexpired term of the leases. In the event voluntary termination negotiations are not successful, condemnation proceedings will be initiated with both State and Federal Governments participating as their interests may appear.

13. It is proposed to notify the lessees of the Government's intent to occupy the area and allow a reasonable time for them to remove the oysters. Such oysters as remain at the time of occupancy will be appraised at the fair market price per acre of growing or matured oysters, with the appraisal to be used as a basis for compensation to the growers.

14. U. S. Navy. The District Engineer was informed by the District Public Works Officer, Fifth Naval District, that the Navy Department will interpose no objection to establishing the disposal area to the north of Craney Island, provided the Navy's interests are amply protected; and provided that the present drainage of Craney Island and property immediately west thereof is not impaired. A formal permit will be obtained from the Navy Department to permit use of its roads at the Craney Island installation, and the construction of a drainage ditch and protective levee adjoining its property.

15. Other agencies. The project as adopted by Congress requires that users of the disposal facilities, other than the Corps of Engineers, shall pay to the District Engineer a fixed unit toll for such use, including the cost of rehandling dredged material into the disposal area, the amount of such toll to be determined by the Chief of Engineers and to include interest on and amortization of the net investment and operation and maintenance costs.

16. Views of local agencies. As evidenced by testimony at the hearing and by written statements (Exhibits 3 thru 14 of project document), local interests strongly endorse the disposal plan. The major oil, shipbuilding, and shipping interests, as well as the City of Norfolk have indicated that a disposal area within close proximity to Norfolk Harbor would be a great asset to all interests who must maintain deep water adjacent to their frontages as well as encouraging new interests to locate in the Hampton Roads area. A dissenting view was voiced by oyster growers regarding the probable operation of the disposal area. These interests are apprehensive of the effects of runoff through the spillways on their inshore oyster grounds leased from the State of Virginia adjacent to and west of the proposed area. They state that the waters west of the area are now nonpolluted and that they are not required to transplant their oysters before harvest and sale as required by State law in the polluted waters of Hampton Roads. Supported in their views regarding the matter by the Commission of Fisheries of Virginia and the Virginia State Health Department, the oyster growers request that the spillways be so located in the retaining structures confining the disposal area as not to release silt and polluted water on their oyster grounds.

D. LOCATION OF PROJECT AND TRIBUTARY AREA

17. Description of harbor. Norfolk Harbor, in Virginia is 300 nautical miles south of New York, 180 nautical miles south of Baltimore, and 25 nautical miles west of the entrance to Chesapeake Bay at Cape Henry, Va. Norfolk Harbor, as locally known, includes a portion of Hampton Roads; Elizabeth River and its Western, Eastern, and Southern Branches; and Scotts Creek, a tributary within the corporate limits of Portsmouth, Va. With the exception of the upper reach of the Eastern Branch, which extends into Princess Anne County, Va., Elizabeth River and its tributaries are situated in Norfolk County, Va. The Elizabeth River is navigable over its entire length; the Eastern Branch is navigable to a point near Kempsville, Va., seven miles above its mouth; the Southern Branch is navigable to Great Bridge, Va., 11 miles above its mouth; the Western Branch is navigable to Bowers Hill, Va., seven miles above its mouth; and Scotts Creek is navigable over its entire length, a distance of approximately one mile. The waters adjacent to Norfolk Harbor, from which all or a portion of dredged material will, in all probability, be deposited are as follows:

Willoughby Channel; Channel from Phoebus, Va., to Hampton Roads; Hampton Creek, Va.; Channel to Newport News, Va.; Portsmouth Harbor, Va.; Channel to Nansemond Ordnance Depot; Lafayette River, Va.; Smith Creek (The Hague); and Paradise Creek, Va.

18. Tributary area. The area tributary to Norfolk Harbor and adjacent waters includes Princess Anne and Norfolk Counties, and a portion of Nansemond County on the south side of Hampton Roads; also, portions of Elizabeth City and Warwick Counties on the west side of Hampton Roads. The area is served by the following eight railroads: Atlantic Coast Line, Chesapeake & Ohio, Norfolk & Western, Norfolk Southern, Pennsylvania (New York, Philadelphia & Norfolk), Seaboard Air Line, Southern, and the Virginian. All of these railroads are interconnected by the Norfolk & Portsmouth Belt Line Railroad. The Belt Line performs interchange switching and serves a large number of industries located on and away from the waterfronts. City streets and secondary roads, practically all surfaced, extend to the shores and terminals of Norfolk Harbor and adjacent waters and connect with the primary highway system. Passenger and vehicle ferries and a vehicular tunnel connect Norfolk with Portsmouth, Newport News, Old Point Comfort, and Cape Charles.

E. DEFINITE PROJECT PLAN

19. Project location. The site selected for the improvement is located on Craney Island Flats adjacent to and immediately north of Craney Island, Va. It extends northerly approximately 11,000 feet and westerly approximately 9,000 feet, and encompasses an area of approximately 2500 acres fronting on property of the U. S. Navy and private waterfront property. (Plates 1 and 2)

20. The proposed plan of improvement would provide a disposal area and two rehandling basins adjacent thereto, conveniently located with respect to dredging activities in the Hampton Roads area. Dredged

material would be transported to the rehandling basins by scows or hopper dredges and dumped. From these basins the dumped material would be moved by a hydraulic dredge through fixed and movable pipelines to the disposal area, where the material would be permanently retained. The use of two rehandling basins is proposed to permit simultaneous operations of dumping and rehandling. The disposal area would be physically separated into three areas by dikes, the long axis of which would extend east and west. These dikes would be constructed hydraulically of rehandled material and the disposal operation would be alternated between the areas, thereby allowing time for drying. Three sluiceways and a pipeline trestle would be constructed immediately after completion of the main levee construction, and their operation would begin with the first deposits of the rehandled material.

21. Plan of improvement. The proposed plan provides a disposal area bounded by sand fill levees to elevation +8.0. The capacity and life of the disposal area are based on eventually filling the area to approximately +18.0. The additional height would be accomplished by constructing step levees inside the original levees as the filling approached the top. It is considered probable that the fill might be carried even higher than elevation +18.0, thereby extending the life of the project. This eventuality, however, was not taken into consideration in arriving at the useful life of the project. The sand portion of the completed levee inclosing the spoil disposal area would have a level top width of 22 feet. The levee would be constructed with a 1 on 2-1/2 slope on the outside covered from elevation +8.0 to -1.0 with 9 inches of crushed stone and 24 inches of nominal 1000-lb. stone, and a 1 on 2 slope on the inside covered from elevation +8.0 to -1.0 with 6 inches of crushed stone and 12 inches of nominal 200-lb. stone. Underwater slopes would be 1 on 30 to approximate elevation -8.0 m.l.w. and 1 on 70 to original bottom. (Plate 5)

22. It is proposed to place three sluiceways in the west retaining levee in order that the disposal area may be divided into stilling basins, and also to insure that spillage from the continuous deposits will be sluiced as far distant as practicable from the Norfolk Harbor 40-foot channel. The sluiceways with flashboards from elevation +2.0 to +7.0, would be of treated pile and timber construction. (Plate 7)

23. Two rehandling basins, each 200 feet by 800 feet and spaced 500 feet apart, would be dredged at a location 600 feet west of the westerly limit of Norfolk Harbor 40-foot channel and directly opposite the center of the disposal area, and 2700 feet from the centerline of the retaining levee. The basins would be initially dredged to a depth of 40 feet at mean low water to provide capacity for material deposited temporarily therein before such material is rehandled to the disposal basin. An approach and exit area, 3800 feet long and 600 feet wide, to connect the rehandling basins with the Norfolk Harbor 40-foot channel, would be dredged to a depth of 31 feet at mean low water to accommodate all drafts of loaded scows and hopper dredges.

24. A trestle, 2500 feet in length, would be constructed between the rehandling basins and the disposal area for the purpose of supporting a discharge pipeline leading from the suction dredge operating in the rehandling basins. The trestle would be of treated pile and timber construction and would have a deck height of +8.0 feet above mean low water. It would be centered approximately between the two rehandling basins and at right angles to the levee centerline. (Plate 6)

25. To meet the need for adequate drainage of adjoining Navy property when the fill in the area progresses shoreward, it is proposed, as an operation and maintenance measure, to excavate a ditch along the north side of Craney Island in a westerly direction to the westerly limit of the disposal area. It would be constructed by dragline method, and the excavated material would be utilized for the construction of a levee adjacent to and north of the ditch. Provision of this ditch would meet the desires of the Commandant, Fifth Naval District, in regard to protection of the interests of the U. S. Navy as well as serving as a retaining levee for material within the disposal basin as it increases in height.

26. Permanent access to the site would be provided by constructing a roadway approximately 3500 feet in length from Virginia State Highway 655 to a junction with the west levee via a route adjacent to the west boundary of the U. S. Naval Refueling Station. This roadway would be used during initial construction and also for subsequent maintenance operations. (Plate 8)

27. Although it is proposed to accomplish the initial construction by contract, the present project estimate is based on operation and maintenance of the disposal facilities being accomplished by government plant and hired labor. However, in view of the fact that large savings in initial cost of the project would result from rehandling of the dredged material by contract in lieu of construction of new plant for the purpose, it is proposed to make a more detailed study of this feature.

28. Since procurement of suitable plant for rehandling purposes is pertinent to the design of certain other features of the project, such as the rehandling basins and pipeline trestle, these items may be modified to some extent and necessitate a separate contract for their construction and revision of the construction schedule. These modifications will be presented with the design memorandum for rehandling plant as a supplement to this report. See Appendix III.

F. FOUNDATIONS

29. Scope of investigations. Foundation investigations consisted of 11 undisturbed drive borings, taken at intervals along the longitudinal axis of the levee. The location and logs of borings are shown on Plate 3. Laboratory tests consisting of confined and unconfined consolidation tests, and shear tests were conducted by the Ohio River Division Laboratories. Long range time settlement, levee slope, and

foundation stability analyses were made. Studies were made to determine the stability of the foundation material against failure by vertical shearing and lateral flow, and estimates were made of the probable displacement of foundation material and consequent settlement of the fill material during the construction period as well as long range settlement predictions. The results of foundation investigations are contained in Appendix I. The settlement due to consolidation of the foundation material will vary from 1 foot near the shore to approximately 7 feet at the northerly limits of the disposal area during the life of the project.

30. Geology. The strata of material underlying the disposal area consist mainly of marine clay interspersed with thin layers of fine to coarse yellow sand or sea shells, or mixtures of these materials. There is a predominance of firm foundation material consisting mainly of sand materials near the shoreline adjacent to Craney Island. The percentage and depth of marine clay increases northward toward and along the northerly limit of the disposal area to a point near the northwest corner of the area where the critical condition exists. At this point the subsurface investigations indicate a marine clay to a depth of 120 feet below mean low water.

G. AVAILABILITY OF CONSTRUCTION MATERIALS

31. Sand. Sand fill materials for the primary construction of the levees to elevation +8.0 is available partly within the limits of the disposal area and the remainder can be obtained near the shoreline adjacent to and west of the disposal area. The locations of sand deposits are shown on Plates 2 and 4.

32. Riprap. Broken stone riprap for construction of the levee revetment is obtainable from quarries near Richmond, Virginia, or from quarries in North Carolina. These quarries are conveniently located near rail transportation. Shipment from either of these sources would be by rail directly to unloading and storage facilities near the site of the improvement.

H. CONSTRUCTION PROCEDURE

33. Levees. The levees would be constructed hydraulically of selected sand material pumped from the borrow areas adjacent to the site. The discharge pipeline would be carried forward along the top of the levee and bleeder pipes would be required in order to limit the spread of fill material laterally and keep it within the prescribed slope limits. As settlement of fill occurred due to displacement of foundation material, it would become necessary to break back the discharge pipeline as many times as needed in order to construct the hydraulic fill to the prescribed height of +5.0 feet above mean low water. (Plate 5)

34. Revetment. Concurrently with the operation of hydraulic filling and only a short distance behind this operation, completion of construction to elevation +8.0 above mean low water and placement of protective revetment on levee slopes would be in progress. In this connection, it would be necessary to provide railroad facilities for storage

and unloading of cars. A suitable access road would be constructed from the railroad site to the levees and the rock would be transported along the top of the levee. Excavation of sufficient side borrow material for use in bringing the levee fill to grade would be accomplished by dragline, and the slopes would be prepared for placing of stone. This would be accomplished by cranes equipped with specially constructed skip pans or rock tongs. The stone would afterwards be smoothed over and chinked with spalls. (Plate 5)

35. Sluiceways. The sluiceways would be constructed after completion of the levee construction by land equipment using the top of the levee as a working base. It would be necessary to excavate through the levee at the site of each spillway to permit the flow of runoff from the rehandling operations through the spillways. (Plate 7)

36. Pipeline trestle. The pipeline trestle and range markers would be constructed by floating equipment. (Plate 6)

37. Access road. An access road would be constructed by land equipment during the first stage of construction. Borrow material for the necessary fill would be available within the limits of the land to be acquired. State Highway 655 would provide suitable access to the site of construction. (Plate 8)

I. SCHEDULE OF CONSTRUCTION

38. Construction schedule. It is estimated that under the most economical procedure, approximately 2-1/2 years would be required to complete the project as a whole. The principal elements of the project would be completed during periods indicated on the construction schedule presented on Plate 9. The construction schedule is discussed in Appendix II. It is proposed to construct the entire project by contract.

39. Fund requirements. The following table indicates the fund requirements for the principal features of the project by fiscal years. The amounts are taken from the detailed estimates in Appendix V, which were based on December 1952 price levels. The cumulative expenditures on the project are shown on Plate 9.

Table 1. Fund Requirements

Description	Allocations to 30 Jun 1953	Fiscal Year Ending 30 Jun 1954	Fiscal Year Ending 30 Jun 1955	Fiscal Year Ending 30 Jun 1956	Total
	$	$	$	$	$
Retaining levees		305,800	2,500,000	2,032,100	4,837,900
Sluiceways				88,500	88,500
Pipeline trestle				193,700	193,700
Rehandling basins and access area				155,800	155,800
Rehandling plant			451,100	1,943,400	2,394,500 (1)
Lands and oyster leases		98,000			98,000
Range markers				26,000	26,000
Access road		28,400			28,400
Navigation aids (U. S. Coast Guard)				11,000	11,000
Planning	89,600	38,900	48,900	800	178,200
Totals	89,600	471,100	3,000,000	4,451,300	8,012,000

(1) Subject to revision with submission of supplemental report. See Appendix III.

J. LANDS AND OYSTER DAMAGES

40. Lands. An additional feature of the initial cost of the disposal facilities is the purchase of 38.2 acres of upland fronting the disposal area west of Craney Island. The acquisition of this acreage would: (1) provide means of shore access to the disposal basin during its construction, operation, and maintenance; (2) eliminate the possibility of damage suits against the United States; (3) permit improvement or modification of drainage conditions if necessary; and (4) permit the unrestricted future use and development of the shore and reclaimed land by the United States. (Plate 2)

41. Oyster damages. The sluicing of sediment-laden and polluted waters through the west levee will cause immediate or early injury to oysters in cultivation on the bottom west of the disposal area. Approximately 1,560 acres of public bottom and 87.8 acres of leased bottom would be affected by sluicing. Ownership of all bottom to be occupied and adversely affected by the disposal operations was vested with the State of Virginia. In compliance with local cooperation requirements set forth in the project document, the State of Virginia has conveyed by deed, dated 19 June 1948, without cost to the United States, all right, title and interest in the submerged land to be occupied by the disposal area. The conveyance is expressly made subject to the rights of lessees of such oyster planting grounds as may be included in the lands conveyed and subject to the provision that the United States shall compensate, at the time of its occupancy, all oyster growers for crops in production, who hold leases from the State of Virginia in the submerged lands conveyed, or any other submerged lands on the south side of Hampton Roads which may be necessary for the construction, operation and maintenance of the project, including dredging for fill material adjacent to the disposal area. The latter provision is in accordance with project document requirements. An opinion has been received from the Attorney General of the State of Virginia clarifying the provision in the aforesaid deed pertaining to "jurisdictional limitations and reservations." The effect of this opinion is to show that there are no reversionary title conditions attached to said deed. The general Assembly of Virginia has also enacted legislation (House Bill No. 381) releasing the United States from all claims for damages as may occur to public or leased oyster beds from the construction, operation and maintenance of the project excepting that the United States shall compensate, at the time of its occupancy, all oyster growers for crops in production who hold leases from the State of Virginia in the submerged lands above described or any other submerged lands on the south side of Hampton Roads which may be necessary for the construction, operation and maintenance of the project, including dredging for fill material adjacent to the disposal area. The latter exception is in accordance with project document requirements. In view of the fact that leases executed by the State of Virginia to private oyster growers are for a term of twenty years each and have no cancellation provisions, and also the fact that there is no statutory authority in Virginia for the State to revoke or cancel these leases, the State of Virginia would have to exercise its power of eminent domain to effect an involuntary termination of the leases of private oyster growers for leaseholds in the disposal area

or on the south side of Hampton Roads. Prior to initiation of work it is proposed for the Government and State to jointly negotiate with the lessees for voluntary termination of these leases; the Government's obligation being limited to merely the crop damage and the State's obligation as to damage, if any, for the unexpired term of the leases. In the event voluntary termination negotiations are not successful, condemnation proceedings will be initiated with both State and Federal Governments participating as their interests may appear. It is proposed to notify the lessees of the Government's intent to occupy the area and allow a reasonable time for them to remove the oysters. Such oysters as remain at the time of occupancy will be appraised at the fair market price per acre of growing or matured oysters, with the appraisal to be used as a basis for compensation to the growers.

42. Gross appraisal. A gross appraisal of the real estate involved and damages to leased oyster bottoms was made by the staff of the District Engineer during October 1952 (Appendix IV). The area involved and values are as follows:

Table 2. Gross Appraisal of Lands

Type	Area	Gross Appraised Value
Waterfront property	38.2 acres	$28,000
Leased oyster bottom	87.8 acres	$44,000

K. OPERATION AND MAINTENANCE

43. Operation of the disposal area will be under the supervision of the District Engineer and will be coordinated with the dredging requirements of the District, local interests, and other government agencies. A discussion of the plant to be used for rehandling purposes, including operation and maintenance thereof, will be presented in a subsequent supplement to this report (see Appendix III). Tentative annual figures for costs of operation and maintenance of the disposal project, assuming new plant, are $646,300 for operation, $227,900 for maintenance of the disposal area only, and $361,400 for plant rental, making a total estimated annual cost of $1,235,600 for operation and maintenance of the disposal area and rehandling plant.

L. COST ESTIMATES

44. Estimated cost. The following table summarizes the estimated costs of the various features comprising the improvement. (See Appendix V) The unit costs in the estimate are based on prevailing prices as of December 1952 (Engineering News-Record Cost Index 587.49).

The total estimated cost of $8,012,000 includes allowances, totaling 25.0 per cent of the estimated direct construction costs plus the appraised value of lands and damages, to cover contingencies, legal and administrative expenses, District office overhead, inspection and supervision, plans and specifications, design memorandum, and other engineering expenses.

Table 3. Summary of Estimated Costs

Item	Estimated Cost at Dec 1952 Price Level
Retaining levees	$4,837,900
Sluiceways	88,500
Rehandling basins and access area	155,800
Pipeline trestle	193,700
Range markers	26,000
Lands and damages to oyster grounds leased from State of Virginia	98,000
Access road	28,400
Navigation aids (U. S. Coast Guard)	11,000
New plant to operate disposal facilities	2,394,500
Preparation of design memorandum and plans and specifications	178,200
Total estimated Federal investment	$8,012,000
Total estimated non-Federal investment	-0-
Total estimated cost of improvement	$8,012,000

45. Annual carrying charges. The estimated economic cost of the project is shown by the following computation of annual carrying charges, based on an estimated life of 22 years:

Federal investment:	
Estimated expenditure (first cost) by the Corps of Engineers for new work	$ 8,001,000
Estimated expenditure by other agencies (U. S. Coast Guard)	11,000
Total Federal first cost	$ 8,012,000
Interest during construction: 2-1/2 per cent for one-half of 2-1/2 year construction period on $5,617,500 (total Federal first cost exclusive of rehandling plant)	175,500
Gross Federal investment	$ 8,187,500
Net salvage value of land to be constructed during estimated useful life of the project.....	2,500,000
Net Federal investment	$ 5,687,500
Federal annual charges:	
Interest at 2-1/2 per cent on $5,793,000 (gross Federal investment exclusive of cost of rehandling plant)	$ 144,800
Amortization at 2-1/2 per cent for 22 years on $3,293,000 (net Federal investment exclusive of cost of rehandling plant)	114,100
Estimated average cost of plant rental ..	361,400
Estimated average cost of maintenance (disposal area and adjacent channels)	227,900
Estimated average cost of operation of disposal facilities	646,300
Total Federal annual charges	$ 1,494,500
Non-Federal investment:	
Net non-Federal investment	$ -0-

Non-Federal annual charges:

Loss of revenue to State of Virginia on oyster ground rental	$	90
Loss of taxes on 38.2 acres of shore property		150
Total non-Federal annual charges	$	240
Total annual charges	$	1,494,740

46. Recovery of rehandling costs. A toll charge would be collected from users of the disposal area other than the Corps of Engineers for rehandling material at the disposal area. The toll for rehandling would be determined by dividing the total Federal annual charges of $1,494,500 by the total number of cubic yards of material to be deposited annually in the disposal area, 4,300,000 from Table 4. This gives an estimated toll charge of approximately $0.348 per cubic yard. The unit toll charge would be favored with the estimated salvage value of the rehandling dredge and attendant plant. In actual operation, the toll to be charged would be determined from the known expenditures for initial construction and procurement of the rehandling dredge and attendant plant. It would be varied periodically throughout the useful life of the disposal facility depending on actual use being made of the area and actual annual operation and maintenance costs. The following tabulation of the quantity of material which is anticipated to be deposited in the disposal area (Table II-1) by using agencies, indicates that charges at the above rate would be recovered from other government agencies and private concerns for rehandling an estimated 1,869,500 cubic yards annually amounting to $650,580:

Table 4. Tabulation of Estimated Annual Deposits and Rehandling Charges by Using Agencies

Using Agency	Estimated Yardage: Hopper Dredging	Estimated Yardage: Bucket Dredging	Estimated Yardage: Total Cu. Yds.	Estimated Recovery from Rehandling Charges at $0.348 per Cu.Yd.
Corps of Engineers	2,350,500	80,000	2,430,500	No charges
U. S. Navy & other Government agencies	901,800	300,000	1,201,800	$ 418,220
Private concerns	- -	667,700	667,700	232,360
Total	3,252,300	1,047,700	4,300,000	$ 650,580

Application of this amount to reduce the annual carrying charges given in par. 45 would result in a net Federal annual carrying charge of $843,920.

M. BENEFITS OF DISPOSAL AREA

47. General. The disposal area would be an asset to the orderly and proper development of the ports of Hampton Roads because the necessity exists for providing an adequate and convenient disposal area to receive material removed by bucket and hopper dredges from channels and berths in Norfolk Harbor and adjacent waters. This necessity has resulted from the progressive reduction due to hydraulic dredging operations, of available shore disposal areas in proximity to improved channels and terminal developments, with a consequential decreased use of hydraulic pipeline dredges, and also the increased operations of bucket and hopper dredges which are rapidly exhausting all convenient natural open-water disposal areas, leaving no alternative but the eventual disposal of dredged material in the Atlantic Ocean off Cape Henry, which would be costly to all parties of interest. The disposal area would result in tangible savings to all users over the cost of disposal in the Atlantic Ocean.

48. Other benefits. Other benefits would accrue from the elimination of the necessity for the large expenditures that would be required of both government and private agencies for the additional plant needed to dispose of dredged material in the Atlantic Ocean. There are no tugs or scows now available in the Norfolk area that are capable of being operated in exposed waters. A combined capital investment of several million dollars would have to be made by all government and private interests if adequate plant for disposing of dredged material in the open sea had to be obtained. This investment would be obviated by the provision of a disposal area at Craney Island. An additional benefit would accrue from the potential value of 2500 acres of reclaimed land at the termination of the project. The estimated annual savings in dredging costs of transporting dredged material to the disposal area in lieu of the Atlantic Ocean, which would benefit private concerns as well as the Federal Government, are shown by the following tabulation of real value of benefits:

Table 5. Summary of Annual Benefits

Estimated Number of Cubic Yards to be Dredged Annually		Estimated Average Cost of Dredging				Estimated Gross Annual Saving		
		With Disposal in Atlantic Ocean		With Disposal in Rehandling Basins without Toll Charge				
		Unit Cost		Unit Cost		Savings per Cubic Yard		Total Savings
Hopper	Bucket	Hopper	Bucket	Hopper	Bucket	Hopper	Bucket	
3,252,300		$0.88		$0.22		$0.66		$2,146,500
	1,047,700 (1)		$1.88		$0.87		$1.01	1,058,200
Total								$3,204,700

(1) Includes 300,000 cu. yds. for other government agencies, 667,700 cu. yds. for private concerns, and 80,000 cu. yds. for Corps of Engineers (Table 4).

In computing these benefits, it was assumed that the hopper dredge "Essayons" would be the most economical plant for dredging the wider channels where space was available for maneuvering. It was estimated that 50 percent of the material to be removed would be from these areas available to the "Essayons." It was further assumed that the schedule for the "Essayons" would permit her to be made available for only 50 per cent of the above dredging. Consequently, dredging costs were based on the use of the "Essayons" for removal of 25 per cent of the yardage, with the remaining 75 per cent to be removed by a dredge of the "Comber" class. It was also assumed that excess material dredged would be approximately equal to the material lost from the rehandling basins. Benefits were therefore based on dredging costs for pay place yardages.

49. Benefit-cost ratio. Comparison of the estimated annual benefits (3,204,700 adjusted real value) with the estimated annual carrying charges ($1,494,740 based on current prices) indicates an adjusted benefit-cost ratio of 2.14 : 1 for the project.

N. RECOMMENDATIONS

50. It is recommended that the definite project plan as presented herein be approved and adopted.

NORFOLK HARBOR, VA.

CRANEY ISLAND DISPOSAL AREA

GENERAL DESIGN MEMORANDUM

SUBMITTED 24 MARCH 1953

REVISED 10 NOVEMBER 1953

APPENDIX I

SOIL DATA AND ANALYSIS

CORPS OF ENGINEERS
U. S. ARMY
NORFOLK DISTRICT

APPENDIX I

SOIL DATA AND ANALYSIS

CONTENTS

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LIST OF TABLES (CONT'D)

EXHIBITS

A. INTRODUCTION

1. SCOPE. This appendix describes (1) the subsurface investigations undertaken for the Craney Island Disposal Area, (2) the laboratory tests conducted in connection with foundation problems, (3) an analysis of slope and foundation soils, and (4) the foundation problems and their proposed treatment.

B. SUBSURFACE INVESTIGATIONS

2. FOUNDATION MATERIALS:

a. Explorations (1944): For the 1945 Survey Report a series of 17 Gow type borings were made along the proposed dike centerline and within the disposal area. No undisturbed samples were obtained and no laboratory tests were made on the materials encountered. Field classification was by visual inspection. Explorations were carried down to depths of -125 feet (MLW Datum), or to hard compacted sand.

b. Explorations (1948): The initial exploration consisted of five drill holes numbered 22 through 26 spaced approximately 5,000 feet apart along the dike centerline, with frequent undisturbed samples taken within the upper 20 feet of foundation, and at greater intervals below that depth. Each hole was carried to hard compact sand. Samples were taken by the piston sampling method in 5-inch diameter seamless steel tubes (Shelby Tubes).

c. Explorations (1949): A second series of drill holes, numbered 81 through 86, located along the dike centerline and spaced midway between the previous five holes, were drilled and sampled in the same manner. Holes 85 and 86 were located near the landside ends of the east and west dike legs, and did not encounter the marine clay layer existing over the major portion of the dike area. No samples were obtained from these two holes. Undisturbed samples from Holes 81 to 84, inclusive, at depths greater than approximately 80 feet were obtained with 3-inch diameter tubes, those from above the 60-foot depth with 5-inch diameter tubes. Each hole was carried to hard compact sand.

Drill Hole	Undisturbed Samples Obtained
22	12
23	9
24	7
25	10
26	9
81	9
82	6
83	10
84	7

d. Description of Materials: The undisturbed samples were generally classified by the laboratories as grey fat marine clays grading into silty clays or silty sands at depths of about -100 feet (MSL). Samples from near the top of holes contained some organic material. All samples contained shells in varying amounts.

e. Laboratory Tests: All samples obtained during the 1948 explorations were forwarded to the former North Atlantic Division Concrete and Soils Laboratory at Ithaca, New York, while those taken from the 1949 explorations were sent to the Ohio River Division Laboratories at Mariemont (Cincinnati) Ohio. Not all of the samples taken and submitted to the laboratories were subjected to tests. Tests made included:

(1) Grain Size Distribution
(2) Specific Gravity
(3) Natural Water Content
(4) Atterberg Limits
(5) Triaxial Shear (Consolidated and Unconsolidated)
(6) Direct Shear (Consolidated)
(7) Consolidation Characteristics
(8) Permeability
(9) Unconfined Compression (1949 Series of Explorations only)

A summary sheet showing the scope of the laboratory testing program is included in this report as Exhibit II.

f. Detailed Test Results: The individual test results are summarized and presented in tabular form on Exhibit III. Detailed laboratory test reports, consisting of laboratory logs and plots of all tests, are presented at the end of this appendix. (Exhibit I)

3. BORROW MATERIALS:

a. Explorations: Approximately forty holes were drilled along and offshore from Craney Island in the vicinity of the shore end of the west leg of the dike to determine the quantity and type of material available for the dike fill. One bag sample (from Drill Hole 33) was taken for laboratory analysis. Since the sand proposed for borrow is located in one general area and was found to be reasonably uniform in character, the one typical sample was considered to adequately represent the entire deposit.

b. Description of Materials: The NAD Concrete Soils Laboratory classified the one sample as a "fine to medium sand, trace of silt." From the grain size curve for the borrow material included in the summary of detailed test results (Exhibit I, Sheets 39 and 40), it appears the material is a uniformly graded fine sand.

c. Laboratory Tests: Grain size distribution, specific gravity, and standard Proctor density tests were made on the one bag sample by the North Atlantic Division Concrete and Soils Laboratory. Results of the tests are shown at the end of this appendix. (Exhibit I, Sheets 39 and 40)

4. ANALYSIS OF STABILITY:

a. Properties of Foundation Materials: All physical and mechanical properties of foundation materials were determined from laboratory tests of selected samples from Drill Holes 22 to 26, inclusive, and 81 to 84, inclusive. The marine clay upon which the pumped sand fill

will be placed was tentatively divided into four horizontal strata, identified as A, B, C, and D, Table I-1.

TABLE I-1 - Location and Description of Soil Zones

Soil Zone	Elevation in feet (MLW Datum) From	To	General Description
A	-10	-30	Grey marine clay
B	-30	-60	Grey marine clay
C	-60	-90	Marine Clay, some silt
D	-90	-110	Clay and silt, some sand
Below D		Greater than-110	Hard compact sand

Limits of each strata were not definite, the arbitrary selection of some depths being primarily an effort to recognize a variation in the clay foundation from the recently deposited soft organic materials near the surface to the compact dense sand which establishes the rigid boundary limit necessary in theoretical analyses of stability and settlement.

(1) Density: In general, dry densities increased with depth, although the fewer number of samples from Zones C and D probably influenced this apparent relationship. Dry densities obtained from laboratory tests are summarized in Table I-2 below. In establishing the single values of dry, saturated, and submerged densities used in stability calculations for this report, more weight was given to the Zone A and Zone B values.

TABLE I-2 - Summary of Densities (Foundation Material)

Soil Zone	Average Natural Densities (p.c.f.) Dry	Saturated	Submerged
A	48.8	93.3	29.3
B	49.7	94.1	30.1
C	57.1	98.3	34.3
D	68.3	103.9	39.9
General Design Memorandum Values	50	96	32

(2) Direct Shear: There was no significant variation in cohesion and tangent ϕ values with depth, possibly because 27 of the 34 separate direct shear tests were made on samples from the upper two soil zones. Average values from consolidated direct shear tests made on undisturbed samples are shown in Table I-3 below:

Table I-3 - Summary of Consolidation Values
(Direct Shear)

Soil Zone	Cohesion (t.s.f.)	Shear Strength (Tan Ø)
A	0.025	0.405
B	0.035	0.416
C	0.046	0.397
D	0.065	0.384
General Design Memorandum Values	0.030	0.400

(3) Triaxial Shear (Unconsolidated): There appeared to be no substantial increase in shear strength with depth, probably due to the relatively few samples representing each foundation zone. Values of unit cohesion and Tan Ø are given below in Table I-4.

Table I-4 - Summary of Consolidation Values
(Triaxial Shear-Unconsolidated)

Soil Zone	Number of Tests	Cohesion (t.s.f.)	Shear (Tan Ø)
A	2	0.15	0.035
B	2	0.13	0.016
C	3	0.24	0.098
D	2	0.17	0.078
General Design Memorandum Values		0.18	0.061

The shear strengths indicated above represent the strength of the foundation before any consolidation due to the embankment weight can occur. This is obviously a conservative or a minimum condition, since some amount of consolidation of the foundation will take place during construction.

(4) Triaxial Shear (Consolidated) There was no apparent variation with depth in the shear strength as determined from consolidated triaxial shear tests. In view of this, and because these shear test samples were not well distributed among the four foundation zones, single average values of unit cohesion and Tan Ø. were established as given in Table I-5 below.

Table I-5 - Summary of Consolidation Values
(Triaxial Shear-Consolidated)

Soil Zone	Number of Tests	Cohesion (t.s.f.)	Shear (Tan ∅)	
A	5	200 0.10	0.187	11.6°
B	0	-	-	
C	3	540 0.27	0.204	11.3°
D	2	760 0.38	0.158	8.9°
General Design memorandum values		0.21	0.186	

It was considered that consolidated triaxial shear tests would indicate in conjunction with consolidated direct shear tests, the strength of the foundation at some time after the completion of construction.

(5) Unconfined Compression: Maximum shear values derived from unconfined compression tests (one-half the ultimate unconfined compressive strength) increased with depth. Variations in test results from individual samples were not unreasonably large. Average values from undisturbed samples are shown in Table I-6 below.

Table I-6 - Average Maximum Shear Values

Soil Zone	Number of Tests	Ultimate Compr. Str. (p.s.i.)	Maximum Shear (t.s.f.)
A	1	0.33	0.012
B	10	1.98	0.072
C	5	4.47	0.161
D	2	5.00	0.180
General Design Memorandum Values		(not established)	

The shear strengths given in the above tabulation are associated with an unconsolidated soft material. As explained previously in sub-paragraph (3), this condition exists only in the case of an instantaneous application of the full embankment load.

b. Properties of Borrow Materials: The laboratory tests on the single sample of sand proposed for the dikes were not sufficient in number or scope to establish a complete set of design properties. Data from published textbooks were used to supplement the laboratory tests in arriving at design values.

(1) Density: Based on the one laboratory Proctor density test, which indicated a maximum unit dry weight of 99 pounds per cubic foot and an accompanying void ratio of 0.700, the following unit weight values were established for the embankment:

Condition	Unit Weight (p.c.f.)
Dry	100
Saturated	124
Submerged	60

(2) Shear: The assumed value of shear strength was based on Article 15 of "Soil Mechanics in Engineering Practice" by Terzaghi and Peck, wherein Table 7 gives a representative value of Ø for loose, dry, uniform round-grain sand of 28.5 degrees. From the same reference it is indicated that saturation will decrease the shear value 1 or 2 degrees. It was considered that a Tan Ø value of 0.450 was conservative, corresponding to a Ø angle of 24.2 degrees, and that cohesion will be zero.

c. Properties of Riprap: No laboratory investigations were made on potential riprap or riprap bedding. Density of these materials was considered to be the same as that of the sand embankment under similar conditions. No shear strength was attributed to the riprap or riprap bedding.

d. Critical Circle Analysis: Stability calculations based on circular arc failure surfaces, using the method of slices developed by W. Fellenius and described in Section 16-15 of "Fundamentals of Soil Mechanics" by D. W. Taylor, were made for four trial circles ranging from a full-depth circle tangent to the hard sand strata at Elevation -110 to a short circular arc entirely within the upper portion of the dike. The rate of consolidation of the marine clay foundation under the relatively light embankment load will be slow, covering a period of several years after completion of construction. Consolidated direct and triaxial shear tests represent the strength of the foundation at this future time. However, during and immediately following the construction period, before appreciable consolidation occurs, the true strength of the foundation is best represented by results of unconsolidated triaxial shear tests. The stability ratios, using the results of unconsolidated tests, range from 1.89 to 5.30, indicating the proposed embankment section and foundation are adequately safe against sliding immediately after construction. Since the strength of the foundation is greater after consolidation has occurred, as indicated by consolidated shear tests, it follows that the stability ratios calculated for a future condition will be even greater than given above. Exhibit IV shows the analysis of the failure arc having the lowest stability ratio of those investigated.

e. Theory of Elasticity Analysis: A study of the shearing stresses created in the marine clay foundation, using the general procedure shown on Figure 90 of the "Notes on Principles and Applications of Soil Mechanics" by USED, Fort Peck, was made for the proposed embankment section. Stresses along the rigid boundary (Elev. -110), at an intermediate depth (Elev. -40), and immediately below ground (Elev. -20) were determined in accordance with the method given in Dr. Leo Jurgenson's paper, "The Application of Theories of Elasticity and Plasticity to Foundation Problems," published in "Contributions to Soil Mechanics, 1925-1940" by the Boston Society of Civil Engineers. The loading diagram used was a rectangular strip load of 500 p.s.f. superimposed upon a triangular strip load of 600 p.s.f. These unit loadings represent the equivalent load produced by the proposed dike section, using unit weights of pumped sand and dumped

riprap given in the preceding paragraphs. Results of the analysis are shown on Exhibit V.

(1) Interpretation of Results: The calculated stress in the top portion of Zone A apparently exceeds the shear strength of the marine clay over a considerable area of the foundation. This condition will become stabilized by displacement of the soft clay near the top of Zone A, by an increase in the foundation shear strength resulting from an intermixing of embankment and foundation materials, and by simple vertical consolidation of the foundation resulting from the weight of the dike.

There will be a zone of over-stressed marine clay approximately 40 feet below the top of the foundation at the dike centerline. However, since the zone will be completely surrounded by material not stressed to full capacity, there will be a transfer of load from the over-stressed to the under-stressed material, and failure is not likely to occur.

(2) Non-Instantaneous Loading: The stress analysis was based on the full embankment load being instantaneously applied to the foundation, a condition that obviously cannot occur. The foundation loading will be gradual, the rate dependent upon the duration of the construction period. It is probable that a slow rate of construction will result in smaller initial stresses in the foundation and also provide greater resisting shear strength which will accompany the partial or continuing consolidation. It is concluded that a slow construction rate would be desirable in that more favorable stress conditions would be set up in the foundation.

f. Sliding Wedge Analysis: Using the theory of composite surfaces of sliding as explained in Article 31 of "Soil Mechanics in Engineering Practice" by Terzaghi and Peck, factors of safety against sliding were determined. Calculation of active and passive earth pressures were based on Article 23 (Equations 23.2, 23.3, 23.5 and 23.6 therein) of the above reference, using unit weights for sand fill and riprap as given in the preceding paragraphs. Two dike sections were analyzed, one with 1 on 30 and 1 on 70 underwater sideslopes (General Design Memorandum proposed section), the other with 1 on 20 underwater sideslopes (alternate section). The horizontal failure surface for each section was assumed to be within the marine clay foundation, immediately below the top surface of Zone A. The shear strength associated with this material, equivalent to one-half the unconfined compressive strength, is only 0.012 tons per square foot. The value for Zone B material was determined to be 0.072 t.s.f. These figures are simple averages of the laboratory test results, grouped according to foundation zones. A better representation of the increase in maximum shear strength (based on unconfined compression tests) with depth is shown in the laboratory test reports of the Ohio River Division Laboratories.

(1) Interpretation of Results: The maximum shear strength appears to increase from a value of approximately 0.010 t.s.f. at the top of Zone A (El. -10) to about 0.040 t.s.f. at the bottom of the zone (El. -30). Minimum values of the calculated stability ratios for those two shear strengths and an intermediate value are given in Table I-7 below.

Table I-7 - Summary of Stability Ratios

Maximum Shear Strength (Zone A) (t.s.f.)	Minimum Stability Ratios	
	General Design Memorandum Section	Alternate Section
0.010	1.05	---
0.025	1.53	1.17
0.040	1.78	1.47

Since there was but one unconfined compressive strength test of Zone A material, and that on clay from near the middle of the zone, the values of maximum shear given above are based primarily on extrapolation from the tests on materials from greater depths. The shear strength near the top of Zone A is particularly questionable, yet it is felt that this value may more nearly represent the actual strength of the very soft clay than do the two larger values, 0.025 and 0.040 t.s.f. Results of the sliding wedge analysis for the two embankment sections, using a maximum shear value of 0.040 t.s.f., are shown on Exhibit VI.

5. ANALYSIS OF FOUNDATION DISPLACEMENT:

a. Zone of Readjustment:

(1) Experience in the Hampton Roads area indicates that there exists a zone or blanket of low density recently deposited marine clay on the bottom of tidal rivers and harbor areas which is readily displaced during dredging operations. The depth of this blanket is not readily determined, but is estimated to average about two to three feet in thickness.

(2) Evidence of the existence of such a layer of semi-fluid material is furnished by the drilling logs of the subsurface explorations for this project. Efforts to obtain undisturbed samples from the nine drill holes of the 1948 and 1949 explorations at depths of -10 to -15 elev. (MLW) were only partially successful, and in only two instances were the samples suitable for laboratory analysis as truly representative of undisturbed foundation material. At several holes the sample washed out of the casing while being withdrawn. From project exploration experience, it is concluded that the low density zone of the foundation extends to an average depth of approximately 2.5 feet.

(3) From laboratory analyses of samples representing material at a depth of approximately four feet below the top of the foundation, it appears that the density of the upper three feet of the foundation is somewhat less than 40 pounds per cubic foot (dry weight). A dry density value of 35 p.c.f. seems reasonable. The difficulty experienced in obtaining undisturbed samples, transporting them to the laboratory, and preparing them for test indicates that the shear and cohesive strengths are negligible, and the material is in a semi-fluid state. Further evidence to support these observations and conclusions may be found in the article by A. Cassagrande titled "The Structure of Clay and Its Importance in Foundation Engineering", contained in "Contributions to Soils Mechanics, 1925-1940," published by the Boston Society of Civil Engineers. The total volume of this estimated 2.5-foot layer of semi-fluid marine cl

clay within the limits of the dike will be approximately 1,900,000 cubic yards.

b. Manner of Readjustment:

(1) During the placing of other underwater hydraulic sand fills in Hampton Roads harbor, it was noted that a mud wave was formed ahead of the fill as it was built up and extended. The sand, as it emerges from the discharge pipe into the water, will roll up a mud wave ahead of the working slope as the dike (and pipe line) are extended along the dike centerline. The wave will reach a limiting height or size, and remain approximately constant in volume during fill operations as a result of entrapping some of the loose material under the sand fill and the lateral movement to the toe of the side slopes of the remaining increment of semi-fluid clay.

(2) The adopted dike section shown on Plate 5 of the Report shows a 1:70 slope below elevation -8.0 at the dike toe. It is estimated that the wedges between the 1:30 and 1:70 slopes at the toe of each side slope will contain approximately 200,000 cubic yards of a heterogeneous mixture of displaced marine clay and the fine sand particles discharged during pumping operations. Of the 200,000 cubic yards, approximately 150,000 cubic yards will be semi-fluid marine clay displaced from beneath the dike area and the remainder will be fine sand discharged during pumping. It is considered that another 150,000 cubic yards of clay will be displaced and dispersed outside the dike limits.

(3) Of the entire 1,900,000 cubic yards of low-density clay, approximately 300,000 cubic yards will be displaced as indicated in the preceding paragraph. The remaining 1,600,000 cubic yards represents only about 350,000 cubic yards of solid particles, at the estimated original in-place density of 35 pounds per cubic foot and a specific gravity of the solids of 2.70. The percentage of voids in the pumped sand fill will probably range between 30 and 35, amounting to about 650,000 cubic yards of volume in the 1,900,000 cubic yards of sand placed in the 2.5-foot zone. Thus there exists ample space in these voids for the 350,000 cubic yards of solid clay particles to be absorbed during the intermixing process without increasing the bulk volume of the 1,900,000 cubic yards of sand fill in the zone.

6. ANALYSIS OF CONSOLIDATION:

a. Properties of Foundation Materials: From the laboratory consolidation tests on all undisturbed cylinder samples, average or typical pressure-void ratio curves representing each of the four foundation zones were established as shown on Exhibit VII. Values of coefficients of consolidation used in the time-settlement predictions are given below.

Table I-8 - Values of Coefficient of Consolidation

Soil Zone	Elevation in Feet (MLW Datum)	Coefficient of Consolidation (Sq. cm. per sec.)
A	-10 to -30	0.000035
B	-30 to -60	0.000050
C	-60 to -90	0.000200
D	-90 to -110	0.002000

b. Properties of Borrow Materials: A moist unit weight of 125 pounds per cubic foot for the dike fill was adopted.

c. Methods of Analysis:

(1) Vertical Displacement: The weight of the dike fill was transformed into two equivalent strip loads, one triangular and one rectangular in section. The schematic load diagram used for determining the amount and rate of settlement was the same as that developed for the Theory of Elasticity stability analysis, and is shown on Exhibit V. Determination of the intergranular preloading pressures within the foundation was made in accordance with Table 12-1 of Taylor's "Fundamentals of Soils Mechanics." Values of post loading intergranular pressures were calculated from Figures 8A and 9 in the article, "The Application of Theories of Elasticity and Plasticity to Foundation Problems," by Dr. Leo Jurgenson, published in the Boston Society of Civil Engineers' "Contributions to Soils Mechanics (1925-1940)." The void ratios associated with the pre- and post-loading pressures were obtained from Exhibit VII herein for each foundation soil zone. Using Equation 12-3 in Taylor's "Fundamentals of Soils Mechanics," the changes in void ratios were converted into linear distances representing the amounts of settlement. This computation procedure was followed for the dike centerline and at 50, 100, and 250 feet from the centerline. In order to establish a range of estimated settlements, similar calculations were made using high, low, and average values of initial void ratios of foundation materials.

(2) Rate of Consolidation: Time-settlement calculations and curves were prepared in accordance with paragraph 12-15 and Figure 10-10 (Case 1) of Taylor's "Fundamentals of Soils Mechanics," based on the average computed settlement at the dike centerline for a 100-foot depth of foundation.

(3) Volume: To estimate the total amount of settlement, in terms of cubic yards, the entire length of dike fill was divided into ten reaches, each containing one or more drill holes. Linear amounts of settlement at the dike centerline and at points 50, 100, and 250 feet from the centerline were then determined for each reach, using the average soil properties for all reaches and foundation depths indicated by the drill hole or holes within the particular reach being considered.

d. Foundation Consolidation: When computed as outlined in paragraph c(1) above, the expected ultimate settlement within the foundation at the centerline of the dike using the average values of

initial void ratio is approximately 7.67 feet. The total amount of additional fill required to provide for this ultimate settlement is slightly less than 3,000,000 cubic yards as shown in Table I-9 below, of which approximately 14 percent, or 420,000 cubic yards, will occur during the construction period. Table I-10 shows the estimated range of ultimate settlement from the mean value of 7.67 feet. Based on the time-settlement curve, as shown on Exhibit VIII, the consolidation within the foundation will be relatively slow, with one-half of the ultimate settlement taking place during first 15 years after start of fill operations.

Table I-9 - Volumetric Settlement of Foundation

Reach No.	Length (feet)	Sectional Area (sq. ft.)	Volume (1,000 cu. yds.)
1	3,000	42	4.6
2	3,000	2,776	308.4
3	3,000	3,310	367.8
4	3,000	4,050	450.0
5	3,000	2,780	310.0
6	3,000	2,780	310.0
7	3,000	3,462	384.8
8	3,000	5,056	539.6
9	3,000	3,400	377.8
10	3,700	98	134.2
		Total	2,987.0

Table I-10 - Linear Settlement of Foundation (100-Foot Depth)

Range of Settlement	At C/L	50 Feet From C/L	100 Feet From C/L	250 Feet From C/L
MAXIMUM	9.34	7.44	5.90	3.52
MEAN	7.67	5.29	4.46	2.71
MINIMUM	6.58	4.69	3.67	2.60

e. Embankment Consolidation: Since the pumped fill forming the embankment will consist chiefly of sand, consolidation will occur very rapidly, very likely being complete within the construction period. No estimate of the amount or rate of such settlement was made.

7. SUMMARY OF BORROW REQUIREMENTS:

The total volume of sand borrow is estimated at approximately 7,670,000 cubic yards, as shown in the following tabulation

Table I-11 - Estimate of Borrow Required

Dike Section (less volume of 1:70 toe wedges)	5,000,000 cu. yds.
Dike toe wedges	200,000 cu. yds.
2-1/2-foot foundation displacement	1,900,000 cu. yds.
Consolidation during construction period	420,000 cu. yds.
Dispersion and leakage during pumping (2%)	150,000 cu. yds.
Total to be pumped	7,670,000 cu. yds.

8. SLUICEWAYS Subsurface investigations show a marine clay stratum underlying the sites of each of the three sluiceways. This stratum extends to a depth of 90 to 120 feet below MLW.

9. PIPELINE TRESTLE: Subsurface investigations of the site of the pipeline trestle reveal a stratum of silt and marine clay underlying the site of the pipeline trestle. The stratum extends to a depth of 104 feet below MLW.

10. REHANDLING BASINS: Subsurface investigations at the site of the rehandling basins revealed soft marine clay to a depth exceeding the planned bottom depth of the basins.

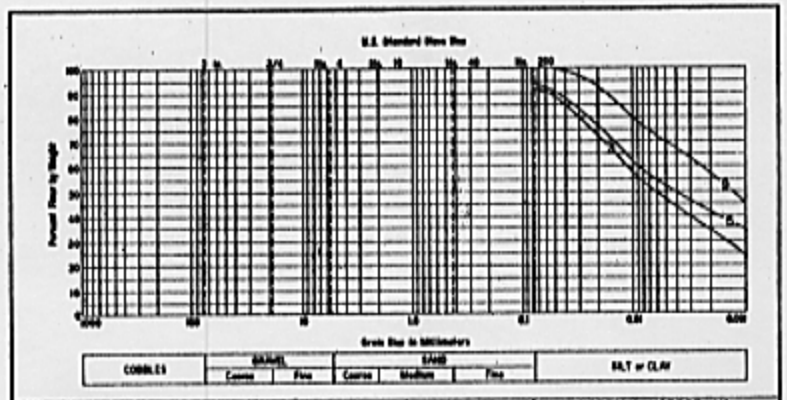
C. FOUNDATION PROBLEMS AND PROPOSED TREATMENT

11. LEVEES: The displacement during the construction period of the marine clay underlying the retaining levees presents a major problem of the construction operations. In order to stabilize the levee base the hydraulic pipeline would be broken back and the pumping repeated as necessary to maintain design grade before the revetment is applied. The fill material would be of sand selected from the limits of borrow area shown on Plate 4.

12. SLUICEWAYS: Construction of the sluiceways would be initiated only after the levees had been completed and foundation consolidation during the construction period had taken place. The pile foundation of the sluiceways was designed to take into account the full frictional value of the sand foundation and the underlying clay substratum. Piles driven in this vicinity and tested by the Navy indicate that although the safe load capacity as indicated by the Engineering News Formula may be very low, a penetration of 50 to 60 feet is sufficient to give a safe bearing capacity of 18 to 20 tons. The computed maximum pile loading for the dead load of the structure plus the maximum live load created by a 30-ton crawler crane plus 25 percent impact would be 18 tons. It may be possible to decrease these indicated lengths slightly during the final design and as a result of pile loading test.

13. PIPELINE TRESTLE: The trestle would be at an elevation of + 8.0 mlw and be subject to severe wave and wind action. The soft clay substratum will be

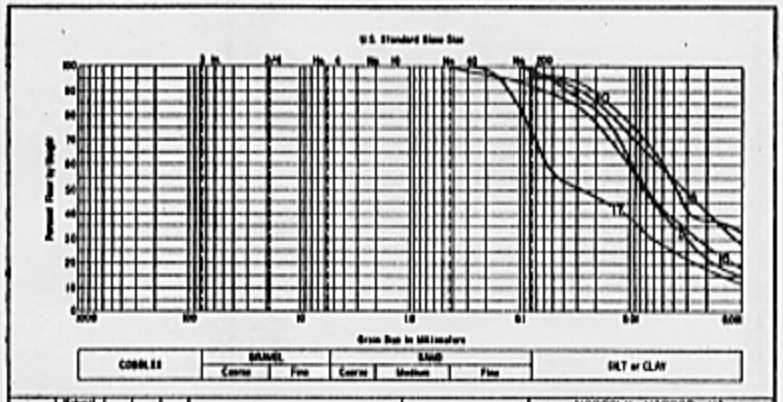
a poor support against side sway and the trestle would necessarily be firmly braced both laterally and longitudinally. The foundation material is marine clay similar to that underlying the sluiceways and pile penetrations would of necessity be large to obtain stability of the structure.



Number	Natural % Moisture	LL	PL	PI	Classification	Remarks
3	86.3	92.5	40.7	51.8	Marine Clay	21.4 - 23.5
6	84.0				Marine Clay	25.6 - 27.7
9	84.8				Marine Clay	51.3 - 52.8

NORFOLK HARBOR, VA.
CRANEY ISLAND DISPOSAL AREA
DRILL HOLE: 22

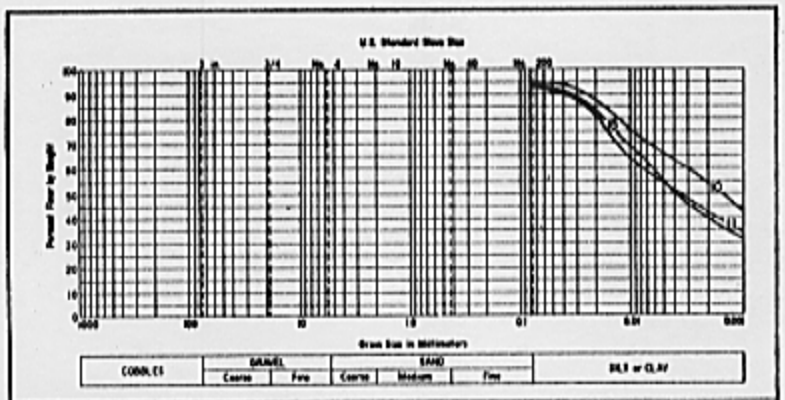
DATE 7 FEB 1949



Number	Natural % Moisture	LL	PL	PI	Classification	Remarks
3	110.6				Marine Clay	14.6 - 16.9
6	94.4	91.6	50.6	50.7	Marine Clay	20.7 - 22.8
10	90.8	96.0	38.5	55.7	Marine Clay	36.7 - 38.8
16	79.8				Marine Clay	91.8 - 93.9
17	47.4	41.8	22.8	19.0	Sandy Silt	113.9 - 115.8

NORFOLK HARBOR, VA.
CRANEY ISLAND DISPOSAL AREA
DRILL HOLE: 23

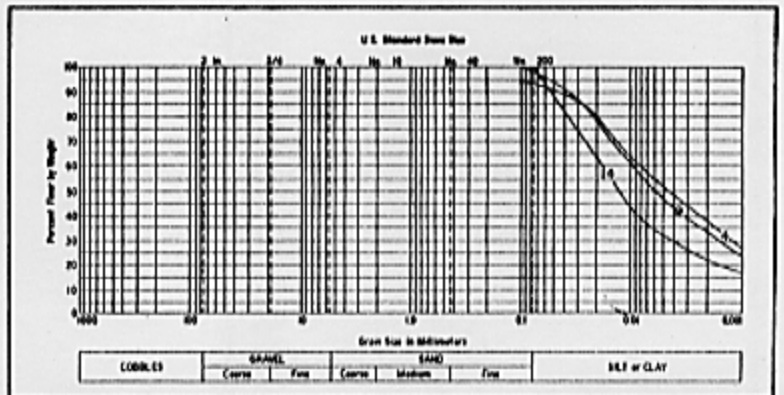
DATE 7 FEB 1949



Number	Natural % Moisture	LL	PL	PI	Classification	Remarks
10	80.0	78.0	31.4	46.6	Marine Clay	61.6 - 63.5
11	76.7				Marine Clay	71.1 - 73.2
15	79.2	88.4	34.6	53.8	Marine Clay	94.3 - 95.8

NORFOLK HARBOR, VA.
CRANEY ISLAND DISPOSAL AREA
DRILL HOLE: 22

DATE: 7 FEB 1949



Number	Natural % Moisture	LL	PL	PI	Classification	Remarks
4	94.7	90.4	28.7	62.1	Marine Clay	17.2 - 19.3
9	82.8				Marine Clay	32.1 - 34.2
14	76.0	91.4	32.6	58.8	Marine Clay	79.8 - 81.9

NORFOLK HARBOR, VA.
CRANEY ISLAND DISPOSAL AREA
DRILL HOLE: 24

DATE: 7 FEB 1949

Exhibit I Sheet 2

WAR DEPARTMENT
Corps of Engineers
North Atlantic Division
U. S. Concrete & Soils Laboratory
Tower Road
Ithaca, N. Y.

11 February 1949

Subject: Transmittal of Laboratory Logs - Norfolk Harbor Disposal Area

To: District Engineer
Norfolk District
Corps of Engineers
Norfolk 1, Virginia

1. Inclosed are laboratory logs, in triplicate, for D.H. 22, 23, 24, 25 and 26 from Norfolk Harbor Disposal Area. These logs include all test results with the exception of five (5) liquid limit tests which will be reported as soon as completed.

2. There are some remaining samples in the laboratory as indicated on the several logs. The samples can be used for any desired additional tests.

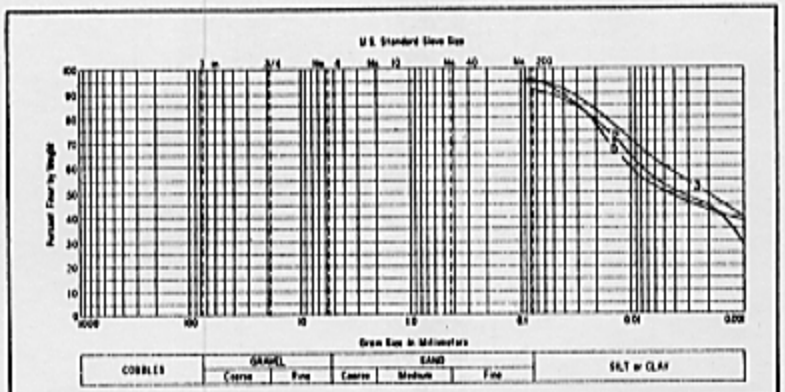
5 Incls. (trip.)
Lab. Logs

F. L. MEARA
Engineer-in-Charge

cc: NAD w/incls.

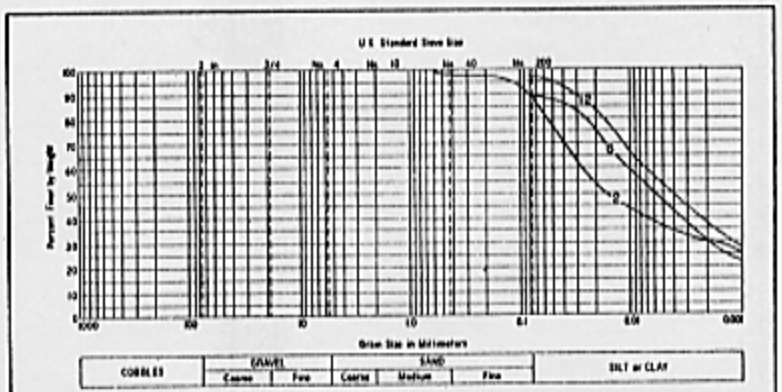
C O P Y

Exhibit I Sheet 1



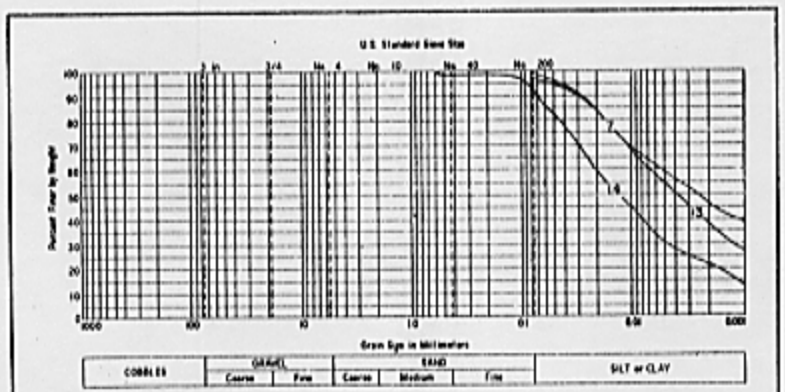
Number	Natural % Moisture	LL	PL	PI	Classification	Remarks
2	83.5				Marine Clay	11.6 - 13.6
3	98.8				Marine Clay	16.6 - 18.7
5		42	29	13	Marine Clay	22.7 - 24.4

NORFOLK HARBOR, VA.
GRANEY ISLAND DISPOSAL AREA
DRILL HOLE: 25
DATE: 3 FEB. 1949



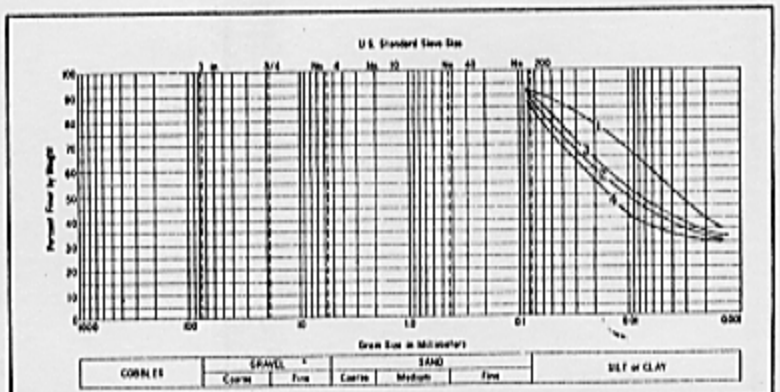
Number	Natural % Moisture	LL	PL	PI	Classification	Remarks
2	78.5	43	25	17.8	Marine Clay	15.6 - 17.7
6	87.4	50	28	21.8	Marine Clay	23.9 - 26.0
12	58.6	47.2	26.8	20.4	Marine Clay	70.7 - 72.8

NORFOLK HARBOR, VA.
GRANEY ISLAND DISPOSAL AREA
DRILL HOLE: 26
DATE: 7 FEB. 1949



Number	Natural % Moisture	LL	PL	PI	Classification	Remarks
7	90.3				Marine Clay	26.6 - 28.6
13	76.3	67	41.5	25.5	Marine Clay	79.6 - 81.6
14	62.8	45.6	30.0	15.6	Clayey Silt	90.7 - 92.8

NORFOLK HARBOR, VA.
GRANEY ISLAND DISPOSAL AREA
DRILL HOLE: 25
DATE: 3 FEB. 1949

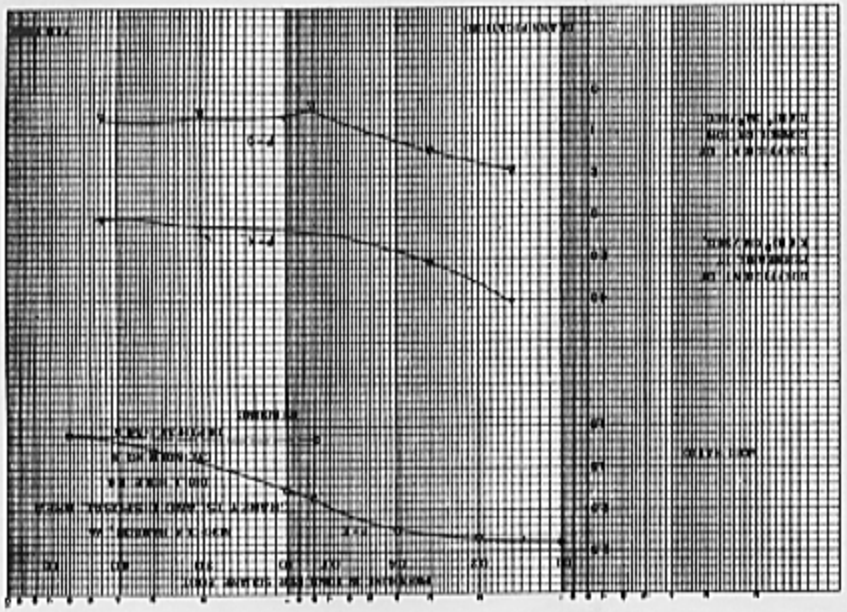


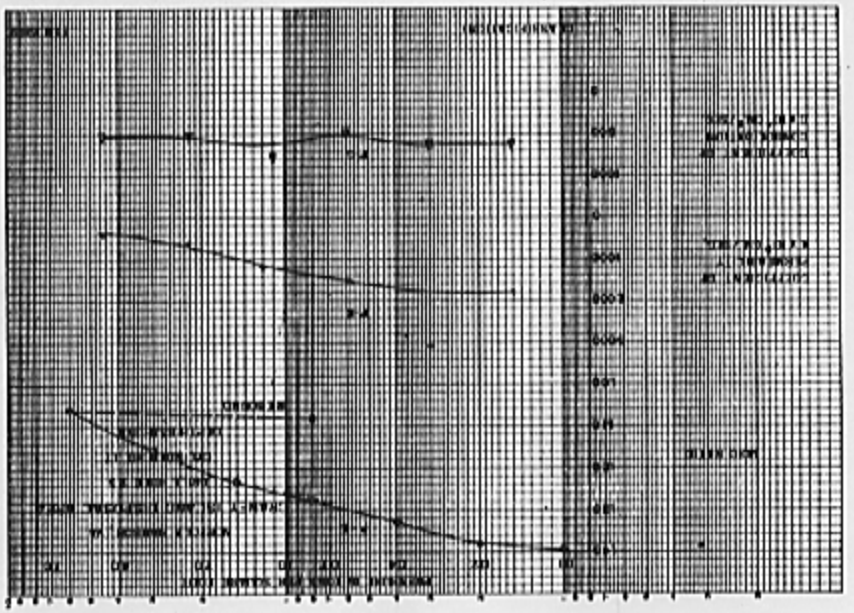
Number	Natural % Moisture	LL	PL	PI	Classification	Remarks
1	109.0	86	43	41.5	Fat Organic Clay (OH)	13.1 - 15.2
2	73.7	64	30	34.4	Fat Clay (CH)	15.2 - 16.9
3	76.7	63	29	33.8	Fat Clay (CH)	21.0 - 23.1
4	72.9	63.5	29.5	34.2	Fat Clay (CH)	25.6 - 26.7

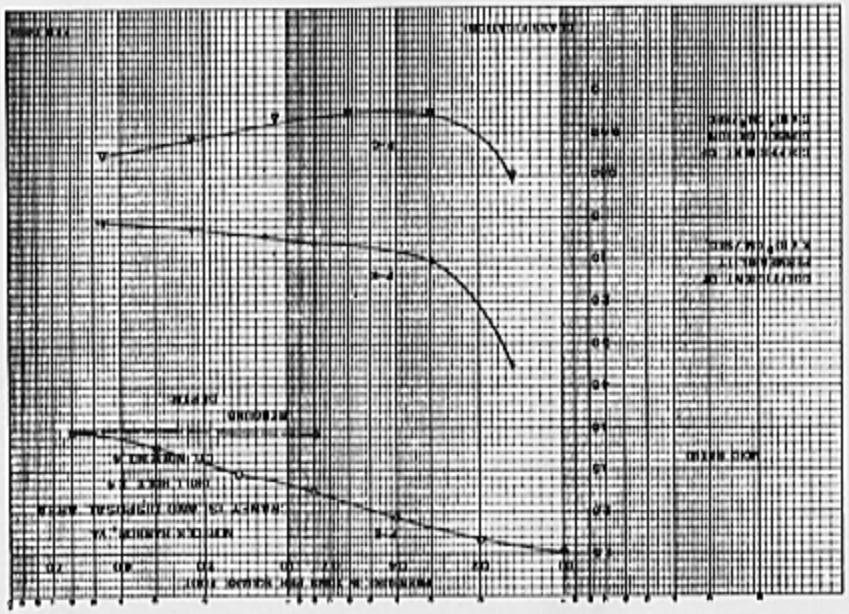
NORFOLK HARBOR, VA.
GRANEY ISLAND DISPOSAL AREA
DRILL HOLE: 81
LOCATION: AXIS OF PROPOSED DIKE
N.W. CORNER OF AREA
TYPE OF SAMPLES: UND. CYL.
ELEVATION TOP OF HOLE = M.L.W.
DATE: JULY 1949

Exhibit 1 Sheet 3

Exhibit I Sheet 4







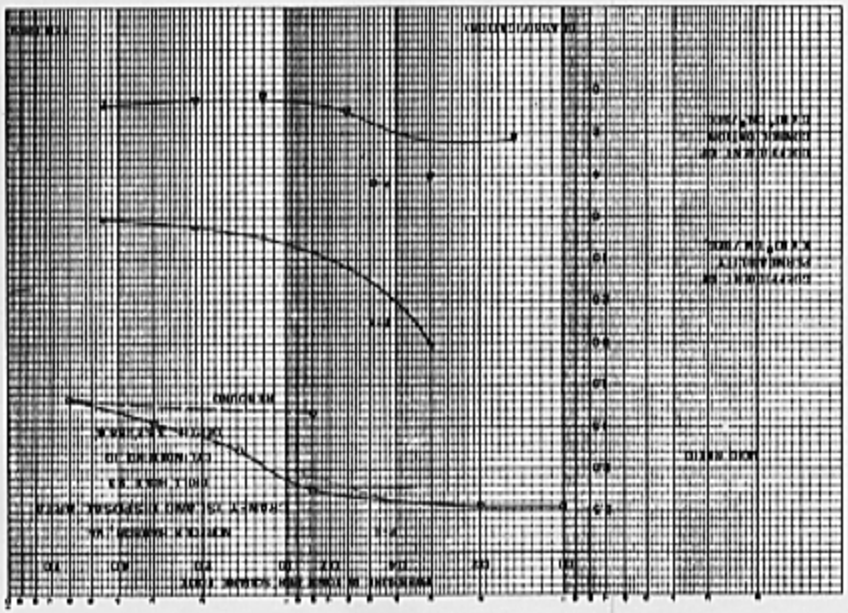
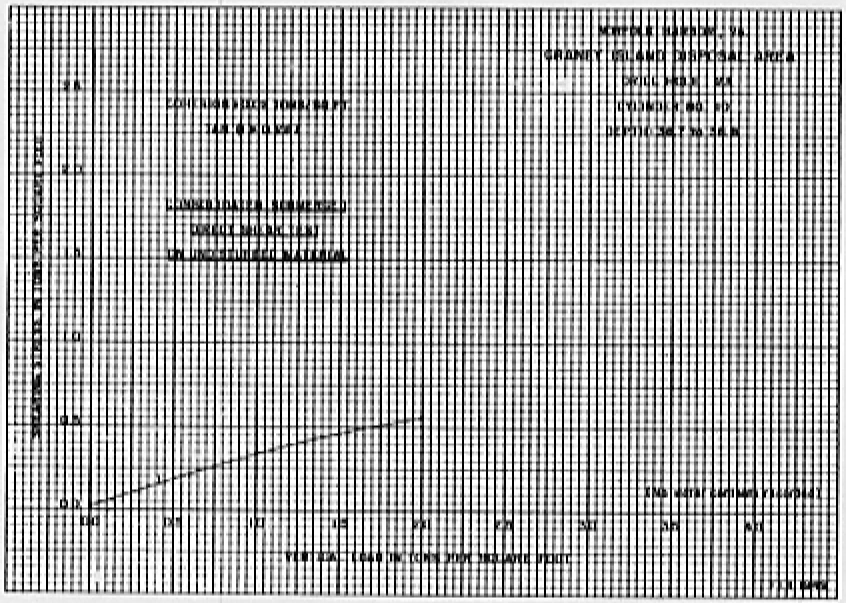


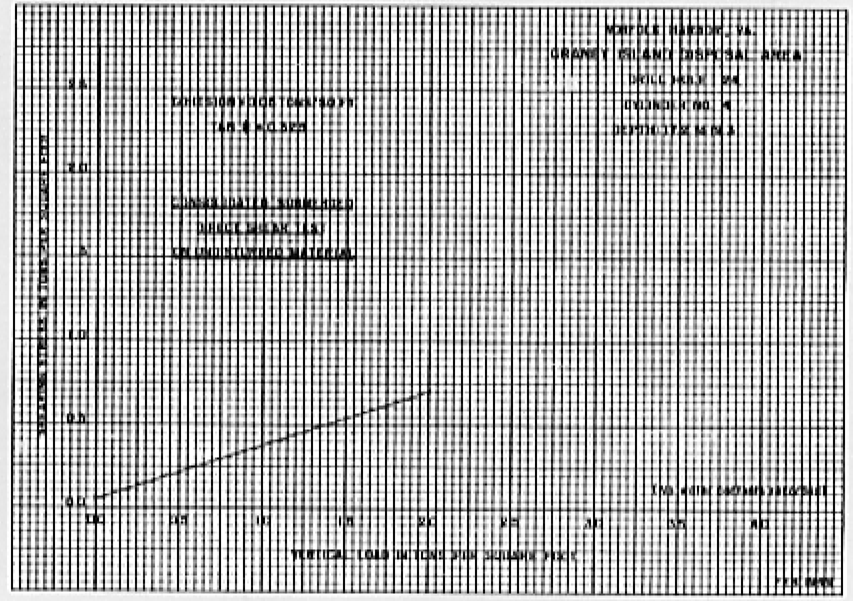
Exhibit I Sheet 5

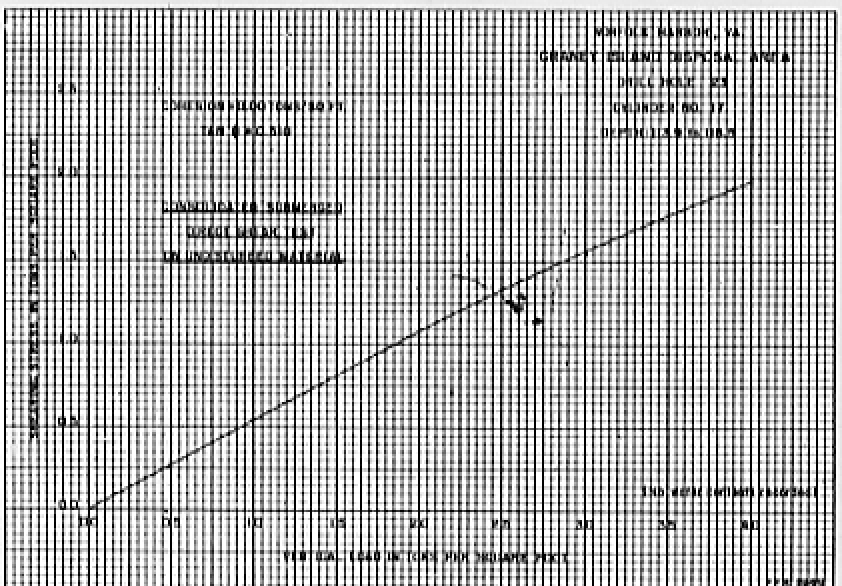
Exhibit I Sheet 6

Exhibit I Sheet 7

Exhibit I Sheet 8







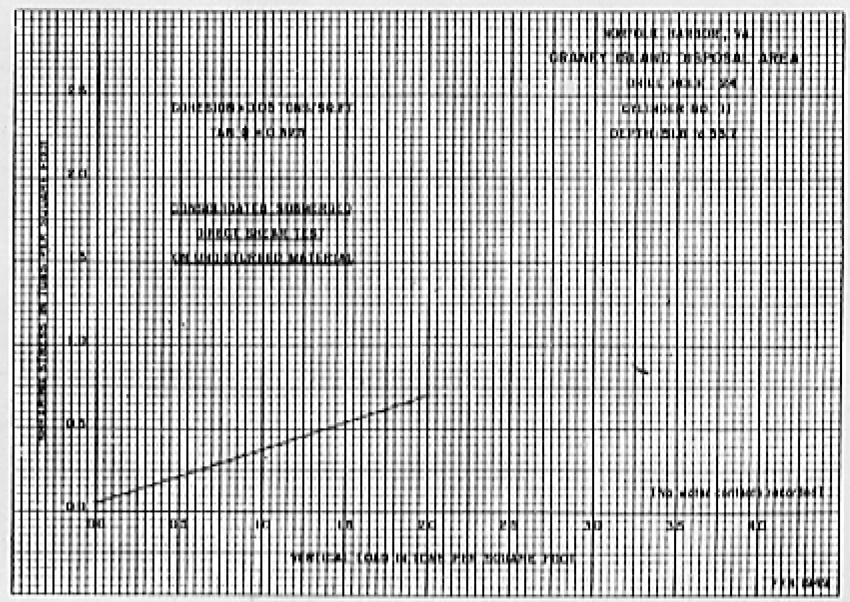
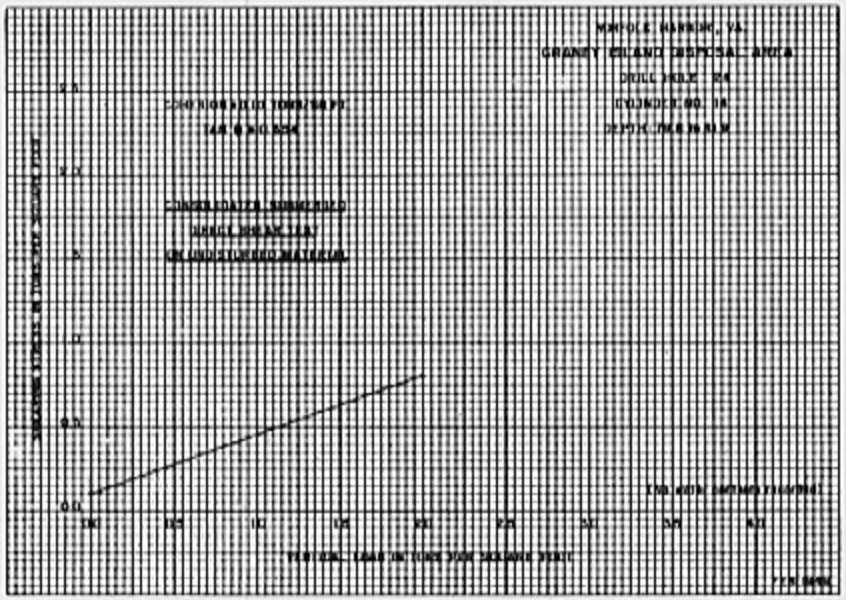
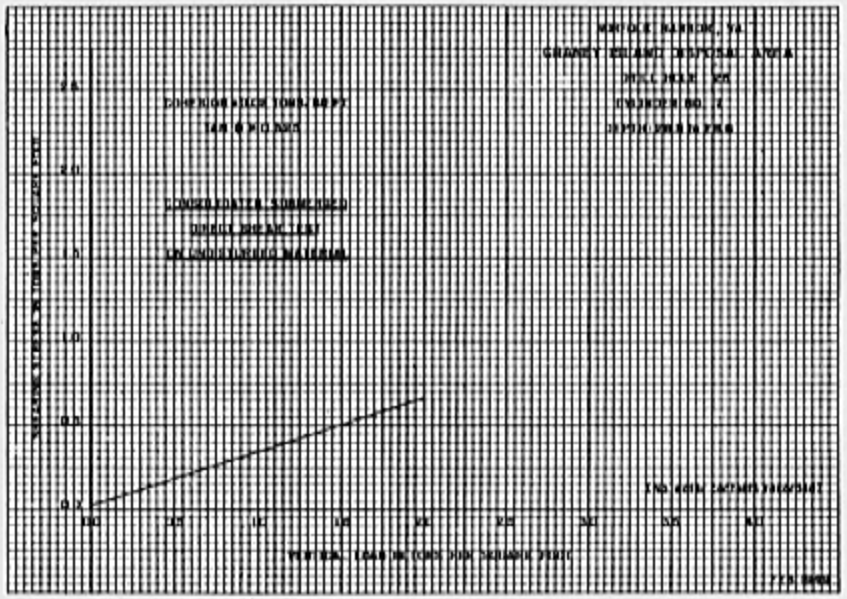
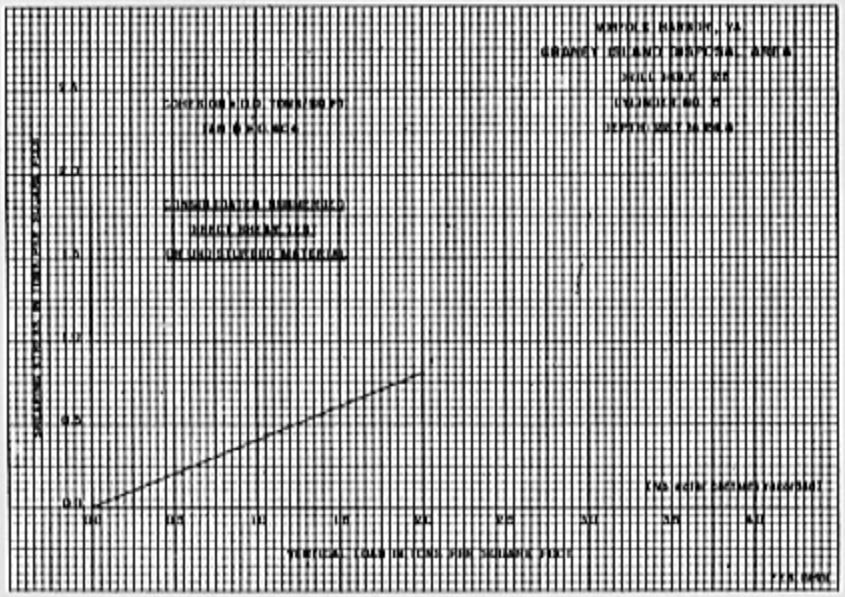


Exhibit 1 Sheet 9







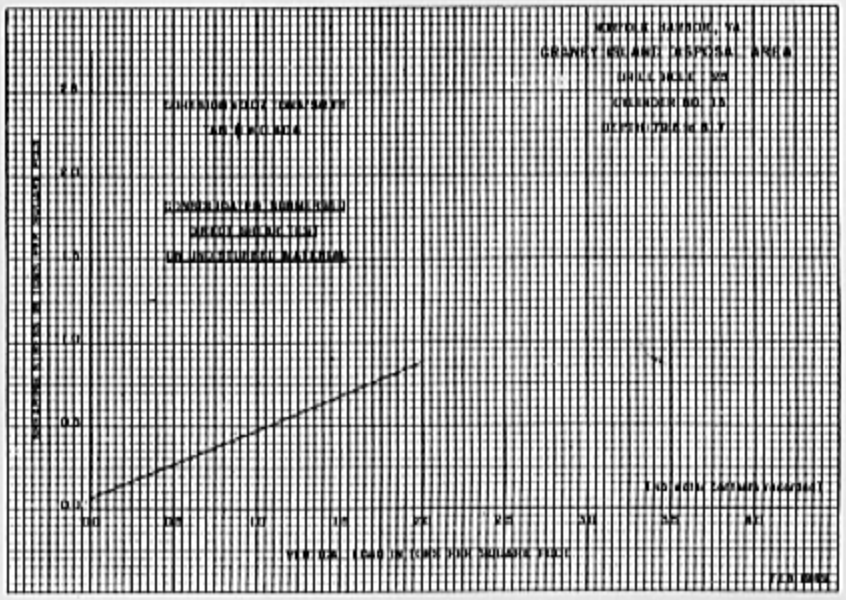
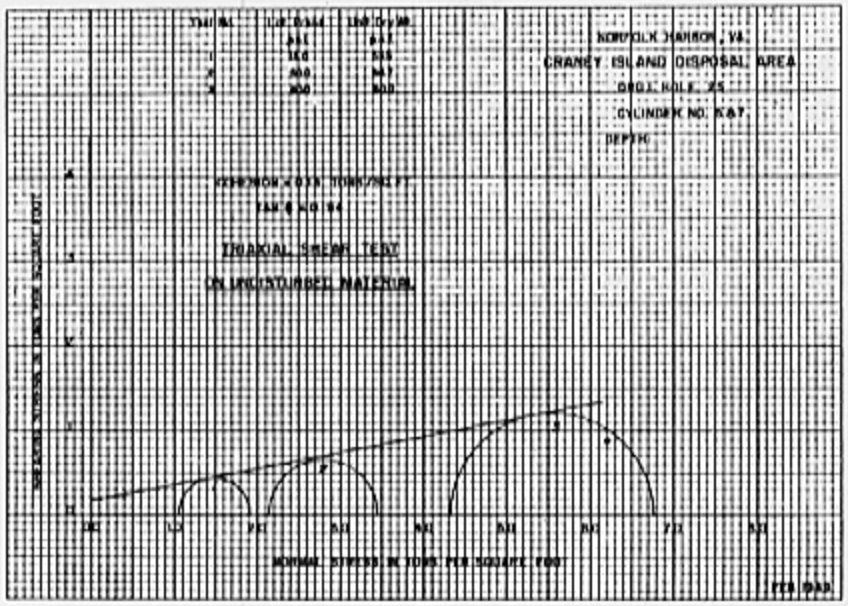
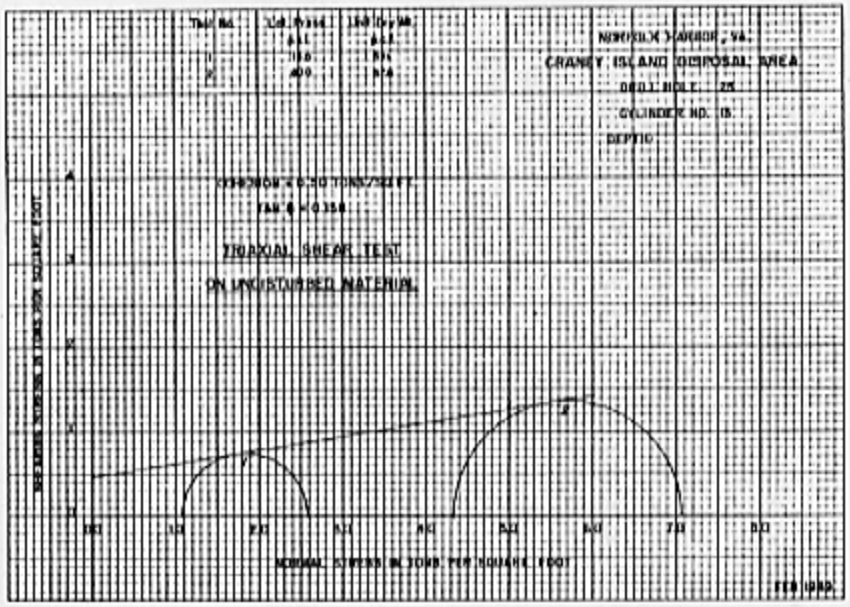


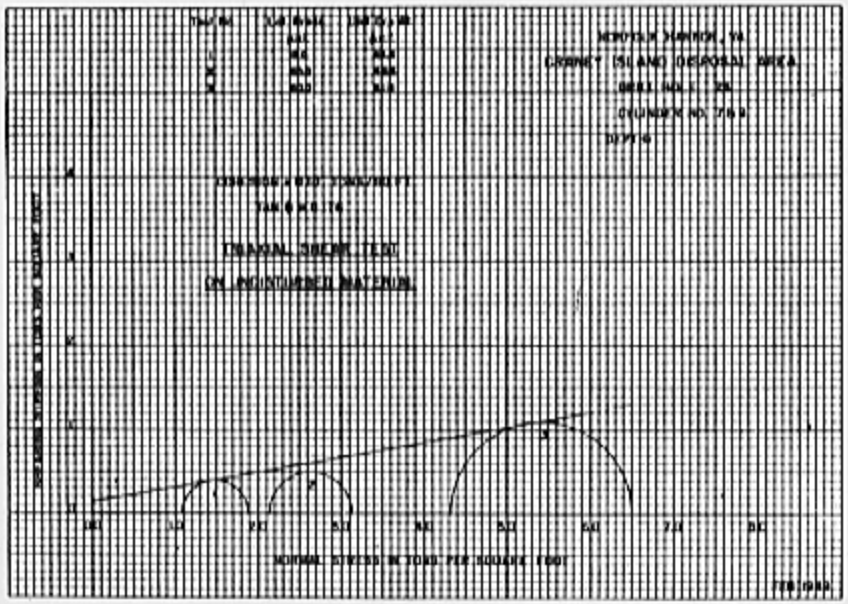
Exhibit I Sheet 10

Exhibit I Sheet 11

Exhibit I Sheet 13







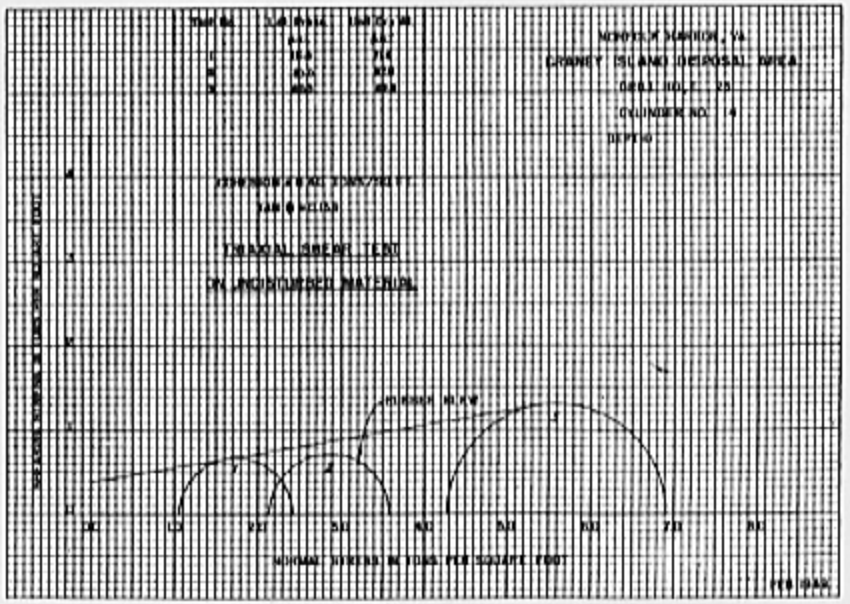
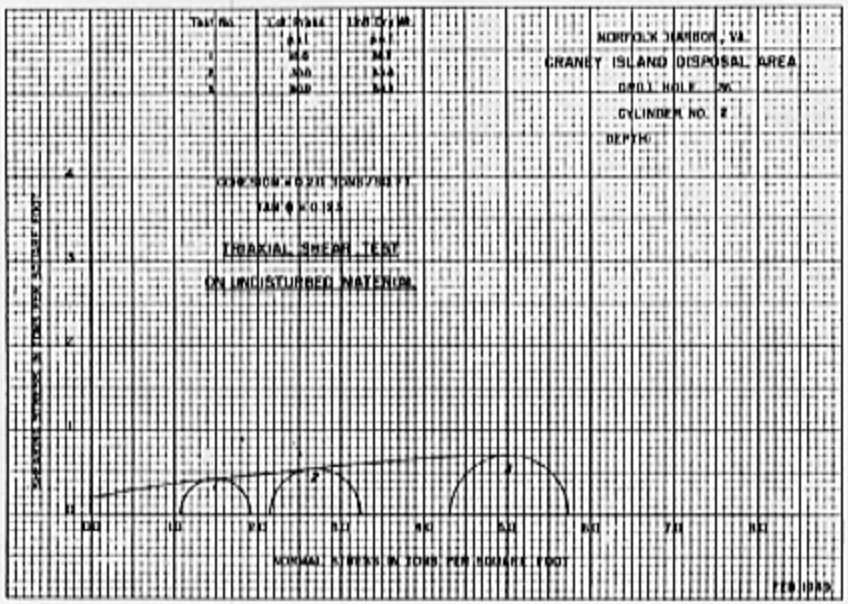
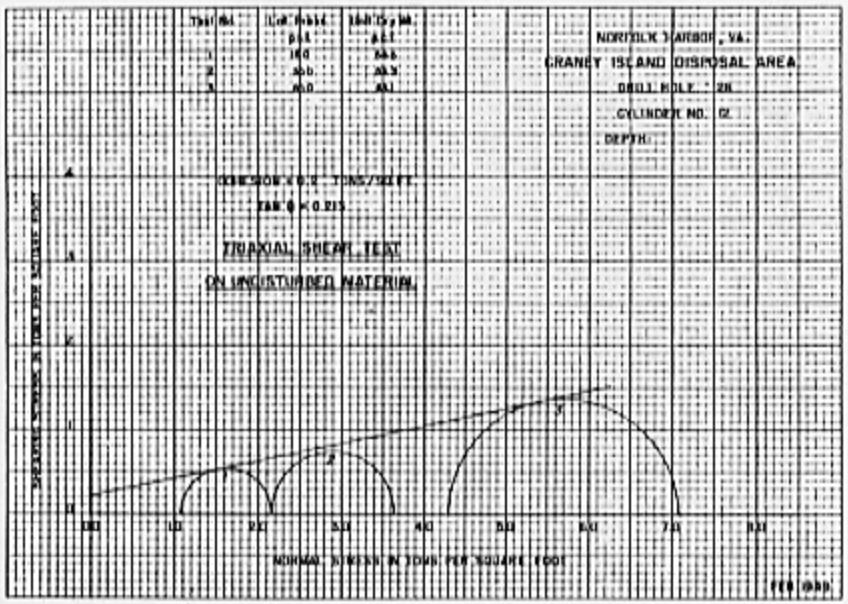


Exhibit I Sheet 14





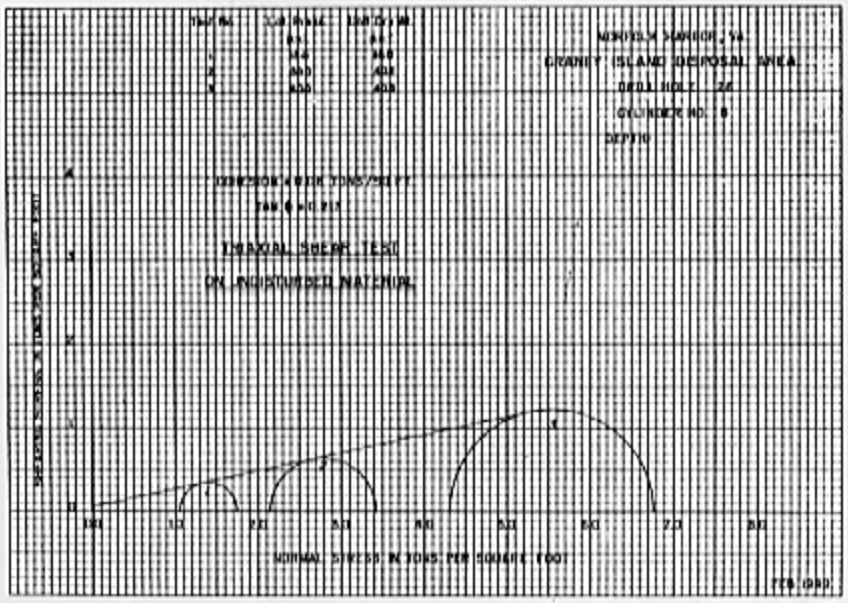


Exhibit I Sheet 15

NAOGD

7 June 1949

SUBJECT: Norfolk Harbor Disposal Area - Laboratory Test Program

TO: Engineer-in-Charge
Ohio River Division Laboratories
5851 Mariemont Avenue, Mariemont
Cincinnati 27, Ohio

1. Reference is made to the conference held in the Ohio River Division Laboratories on 26 May 1949 between members of those laboratories and members of the Norfolk District, for the purpose of discussing field exploration and laboratory testing required for the subject project.

2. In accordance with procedures agreed upon at the conference, there are being forwarded by air express, this date, the following samples of Marine Clay from Drill Holes 81 and 82, the locations of which are shown on the accompanying plans.

Hole No.	Sample No.	Elev (M.L.W.)	Diameter in Inches
81	1	-13.1 to -15.2	5
	2	-15.2 to -16.9	5
	3	-21.0 to -23.1	5
	4	-25.6 to -26.9	5
	5	-35.5 to -37.5	5
	6	-45.5 to -47.6	5
	7	-55.5 to -57.6	5
	8	-75.0 to -77.1	3
	9	-96.4 to -98.3	3
82	1	-12.6 to -14.7	5

A copy of the driller's log for drill hole No 81 is attached. Additional samples from drill holes 82, 83, 84, and 85 will be shipped upon completion of the holes. Drill hole 86 has been completed but did not encounter any substantial clay layer.

3. Laboratory tests are desired to determine the following properties and variation of properties with depth of clay deposit:

a. Grain size distribution
b. Specific gravity
c. Atterberg limits
d. Water content

C O P Y

e. Consolidation characteristics
f. Unconfined compressive strength
g. Shear Strength

4. The appropriate cost symbol for this work is NH 1-a

5. It is requested that the sample boxes and sponge rubber pads be returned to the Norfolk District at an early date.

FOR THE DISTRICT ENGINEER:

2 Incls
1. Cy Boring Log
2. Plans, Norfolk Harbor Disposal Area

H. C. ROWLAND, JR.
Lt. Colonel, Corps of Engineers
Chief, Engineering Division

C O P Y

SUBJECT: Norfolk Harbor Dis. Area-Lab.Test Program(Ltr fm DE, Norfolk, to ORD Labs, 7 June 49).

OVDWE 49S38-Z 1st Ind. JAF/mcc
Ohio River Division Laboratories, Mariemont, Ohio, 27 December 1949.

TO: District Engineer, Corps of Engineers, Norfolk 1, Virginia.

1. The test program set up in the basic letter has been completed and the test results are submitted herein.

2. The soil samples included in the test program are listed in the basic letter and by three subsequent letters bearing the same title and dated 27 June 1949, 9 September 1949 and 6 October 1949. These listings are summarized by the following tabulation.

Identification of Samples Received and Tested

Hole No.	Undisturbed Sample No.	Elev. (M.L.W.)	Diameter in Inches
81	1	-13.1 to -15.2	5
	2	-15.2 to -16.9	5
	3	-21.0 to -23.1	5
	4	-25.6 to -26.9	5
	5	-35.5 to -37.5	5
	6	-45.5 to -47.6	5
	7	-55.5 to -57.6	5
	8	-75.0 to -77.1	3
	9	-96.4 to -98.3	3
82	1	-12.6 to -14.7	5
	2	-31.9 to -34.0	5
	3	-41.4 to -43.5	5
	4	-54.4 to -56.5	5
	5	-76.5 to -78.4	3
	6	-95.7 to -97.8	3
83	1	-10.4 to -12.5	5
	2	-13.6 to -15.7	5
	3	-26.8 to -28.9	5
	4	-29.7 to -31.8	5
	5	-34.8 to -36.9	5
	6	-44.2 to -46.2	5
	7	-53.4 to -55.5	5
	8	-74.9 to -77.0	3
	9	-94.5 to -96.5	3
	10	-104.4 to -106.5	3

C O P Y

84	1	-11.1 to -13.2	5
	2	-13.7 to -15.5	5
	3	-20.8 to -22.7	5
	5	-34.9 to -37.0	5
	6	-45.0 to -47.1	5
	7	-55.0 to -57.1	5
	8	-73.1 to -75.2	3

3. In order to aid in the interpretation and use of the test results the testing procedures used are outlined briefly as follows:

a. Classification Tests: Mechanical analyses were made by standard sieve and hydrometer methods. Atterberg limit tests were made in accordance with ASTM Designations D423-39 and D424-39. Based upon the results of these tests the samples have been classified according to the Pamphlet prepared by the Office of the Chief of Engineers, subject: "New Tentative Soil Classification for the Corps of Engineers" dated 8 February 1949.

b. Consolidation Tests: For each consolidation test an undisturbed specimen was cut from the sample into the consolidation "ring" after which the ring and specimen were placed in the consolidation device. The five-inch 2.0-tons per square foot, respectively, applied at 48-hour intervals. For the 0.30, 0.60, 1.2 and 2.4-tons per square foot. Vertical deformations were recorded for each load increment at the following elapsed time intervals after the application of each load: 5, 10 and 15 seconds; 1, 2.25, 4, 6.25, 9, 16, 25, 36, 49, 64, 81, 100, 121, 144, 169, and 196 minutes. After the last loading cycle was completed the sample was allowed to "rebound" under zero load. The final water content of the specimen was determined after completion of the test.

c. Direct Shear Tests: Slow consolidated direct shear tests were made on the undisturbed samples by preparing several specimens from each sample. Each specimen was allowed to consolidate and drain under the normal load at which it was subsequently tested. The normal loads used ranged from 0.25 to 2.0 tons per square foot. The consolidation period was usually about 44 hours. The shear stress was then applied at a rate to cause a constant horizontal movement of 0.001-inches per minute throughout the test. Horizontal and vertical deformations and the shearing stress were recorded at 5 minute intervals. The maximum shear stress and the final water content determined for each specimen are shown in the test results.

d. Triaxial Shear Tests: Triaxial shear tests were made for undisturbed specimens 2.8-inches in diameter by approximately 5.6-inches in height. The tests were made on the specimens at natural water content. No consolidation was permitted before the test, but drainage was allowed during the test. Lateral pressures of zero and 10 psi. were used. A constant strain triaxial compression machine was utilized, the strain being applied at a rate of

C O P Y

approximately 0.00019-inches per inch per second. Each test was carried to failure. Stress-strain curves and Mohr's stress diagrams have been prepared for each test. The initial or natural water content, unit dry weight and void ratio were determined for each triaxial specimen.

e. Unconfined Compression Tests: When only one specimen could be obtained from a given sample it was tested at zero lateral pressure. These tests were designated as "unconfined compression tests". The testing procedure was identical with that used for the triaxial shear tests.

4. Test Results: All of the test results obtained are shown by the inclosed figures and laboratory logs. Included in the figures are plots showing the variation of properties with depth for each hole. The properties so plotted are as follows:

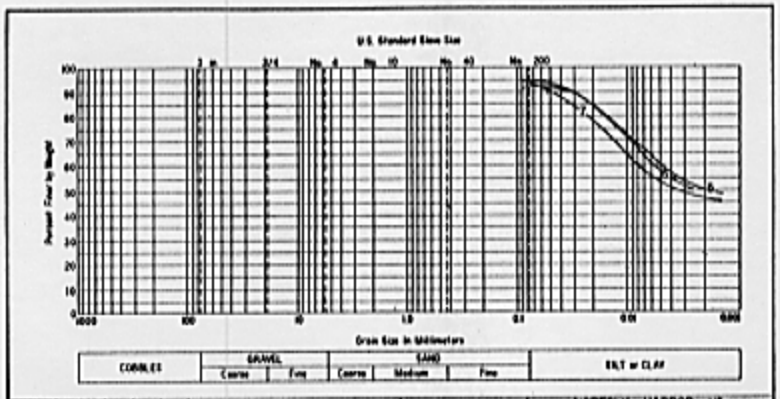
a. Natural water content
b. Atterberg limits
c. Void Ratio
d. Maximum shear stress
e. Unit cohesion and tan ϕ
f. Specific gravity

FRANK M. MELLINGER
Engineer

2 Orig. Incls: w/d

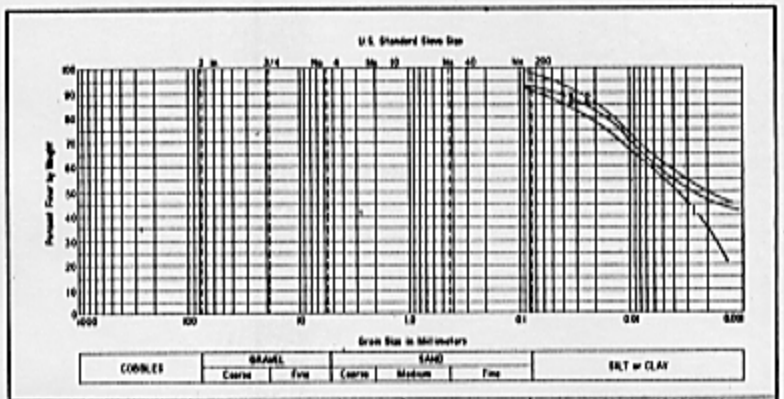
1 Incl. added: Set of 117 Figures (tripl)

C O P Y



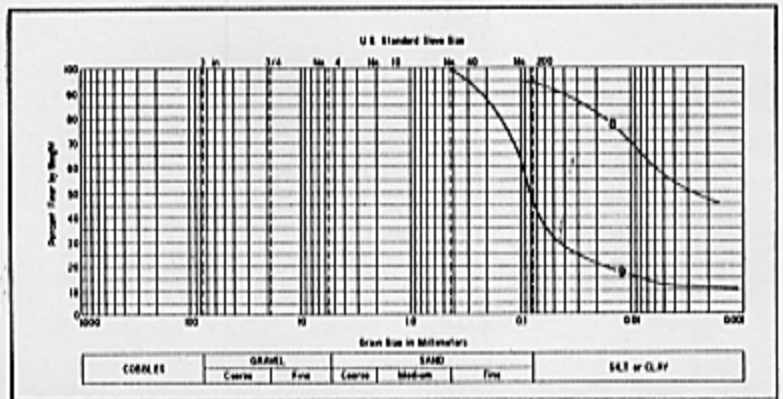
Number	Natural % Moisture	LL	PL	PI	Classification	Remarks
6	95.1	127	82	45.1	Fat Clay (CH)	35.5 - 37.5
8	94.7	83.5	34.2	49.1	Fat Clay (CH)	45.5 - 47.6
7	77.4	71.4	27.8	43.6	Fat Clay (CH)	55.5 - 57.6

NORFOLK HARBOR, VA.
GRANEY ISLAND DISPOSAL AREA
DRILL HOLE 81
LOCATION AXIS OF PROPOSED DIKE
N.W. CORNER OF AREA
TYPE OF SAMPLES: UND. CYL.
ELEVATION TOP OF HOLE = M.L.W.
DATE: JULY 1949



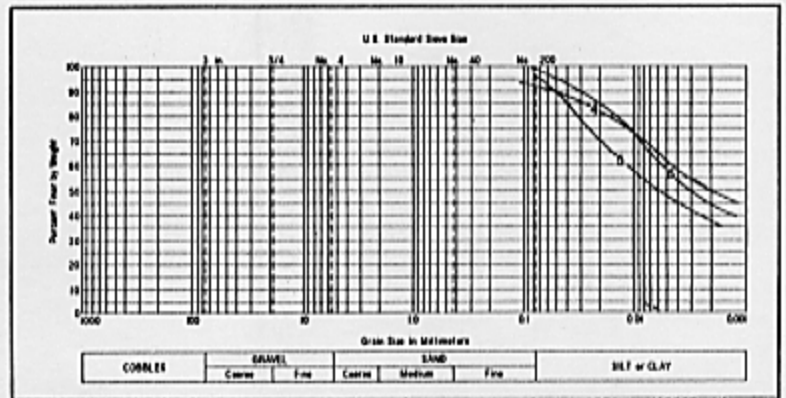
Number	Natural % Moisture	LL	PL	PI	Classification	Remarks
1	73.5	78.1	36.8	41.3	Fat Organic Clay (OH)	12.6 - 14.7
2	80.5	73.6	29.7	43.9	Fat Clay (CH)	31.9 - 34.0
3	83.6	83.8	38.6	45.2	Fat Organic Clay (OH)	41.4 - 43.8

NORFOLK HARBOR, VA.
GRANEY ISLAND DISPOSAL AREA
DRILL HOLE 82
LOCATION: AXIS OF PROPOSED DIKE
N.E. CORNER OF AREA
TYPE OF SAMPLES: UND. CYL.
ELEVATION TOP OF HOLE = M.L.W.
DATE: JULY 1949



Number	Natural % Moisture	LL	PL	PI	Classification	Remarks
8	85.2	80.5	40.5	40.0	Fat Organic Clay (OH)	78.0 - 77.1
9	21.4	NON-PLASTIC			Sandy Silt (ML)	96.4 98.3

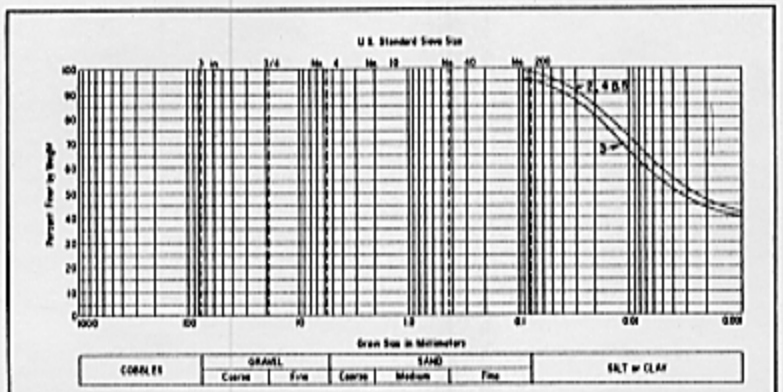
NORFOLK HARBOR, VA.
GRANEY ISLAND DISPOSAL AREA
DRILL HOLE: 81
LOCATION AXIS OF PROPOSED DIKE
N.W. CORNER OF AREA
TYPE OF SAMPLES: UND. CYL.
ELEVATION TOP OF HOLE: = M.L.W.
DATE: JULY 1949



Number	Natural % Moisture	LL	PL	PI	Classification	Remarks
4	79.4	89.0	37.6	51.5	Fat Clay (CH)	54.4 - 56.5
5	80.3	87.1	29.4	58.3	Fat Clay (CH)	76.5 - 78.4
6	78.0	75.6	35.7	39.9	Fat Organic Clay (OH)	95.7 - 97.8

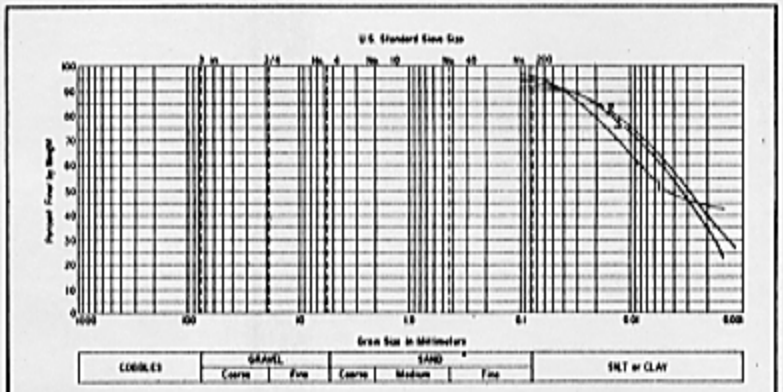
NORFOLK HARBOR, VA.
GRANEY ISLAND DISPOSAL AREA
DRILL HOLE 82
LOCATION: AXIS OF PROPOSED DIKE
N.E. CORNER OF AREA
TYPE OF SAMPLES: UND. CYL.
ELEVATION TOP OF HOLE = M.L.W.
DATE: AUG. 1949

Exhibit I Sheet 18



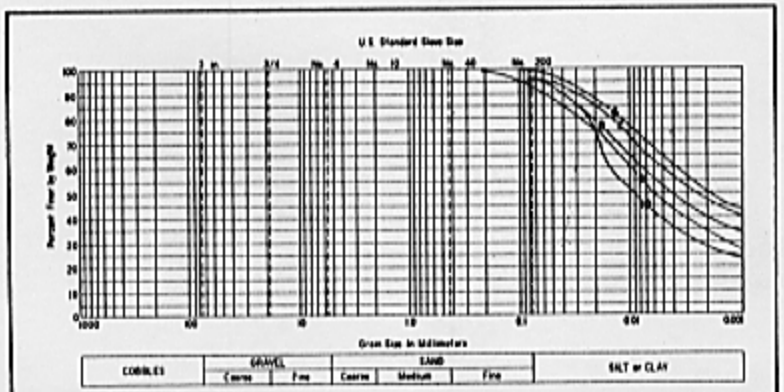
Number	Natural % Moisture	LL	PL	PI	Classification	Remarks
2	69.9	84.4	28.8	56.6	Fat Clay (CH)	13.6 - 15.7
3	85.8	82.8	27.3	55.5	Fat Clay (CH)	28.8 - 28.9
4	83.7	76.5	26.7	49.8	Fat Clay (CH)	29.7 - 31.8
5	86.7	84.4	29.1	55.3	Fat Clay (CH)	34.8 - 36.9

NORFOLK HARBOR, VA.
CRANEY ISLAND DISPOSAL AREA
DRILL HOLE 83
LOCATION: AXIS OF PROPOSED DIKE
EAST SIDE OF AREA
TYPE OF SAMPLES: UND. CYL.
ELEVATION TOP OF HOLE = M.L.W.
DATE: NOVEMBER 1949



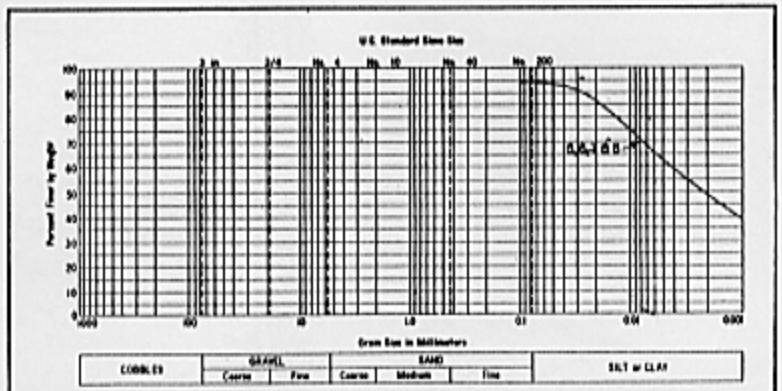
Number	Natural % Moisture	LL	PL	PI	Classification	Remarks
1	141.8	92.0	32.5	59.5	Fat Clay (CH)	11.1 - 13.2
2	122.1	89.2	29.2	60.0	Fat Clay (CH)	13.7 - 15.8
3	101.8	87.4	32.4	55.0	Fat Clay (CH)	20.8 - 22.7

NORFOLK HARBOR, VA
CRANEY ISLAND DISPOSAL AREA
DRILL HOLE 84
LOCATION: AXIS OF PROPOSED DIKE
WEST SIDE OF AREA
TYPE OF SAMPLES: UND. CYL.
ELEVATION TOP OF HOLE = M.L.W.
DATE: OCTOBER 1949



Number	Natural % Moisture	LL	PL	PI	Classification	Remarks
6	92.0	99.1	29.8	69.3	Fat Clay (CH)	44.2 - 46.2
7	91.9	94.8	30.4	64.4	Fat Clay (CH)	53.4 - 55.5
8	73.2	78.5	29.8	48.4	Fat Clay (CH)	74.9 - 77.0
9	88.5	104.8	44.1	60.7	Fat Clay (CH)	94.5 - 96.5
10	58.3	67.8	30.7	37.1	Fat Clay (CH)	104.4 - 106.8

NORFOLK HARBOR, VA.
CRANEY ISLAND DISPOSAL AREA
DRILL HOLE 83
LOCATION: AXIS OF PROPOSED DIKE
EAST SIDE OF AREA
TYPE OF SAMPLES: UND. CYL.
ELEVATION TOP OF HOLE = M.L.W.
DATE: NOVEMBER 1949



Number	Natural % Moisture	LL	PL	PI	Classification	Remarks
6	88.1	91.7	32.2	59.5	Fat Clay (CH)	34.2 - 37.0
6	88.8	93.4	33.7	59.7	Fat Clay (CH)	45.0 - 47.1
7	95.7	93.6	35.8	57.8	Fat Clay (CH)	65.0 - 67.1
8	94.5	92.0	37.2	54.8	Fat Clay (CH)	73.1 - 75.2

NORFOLK HARBOR, VA.
CRANEY ISLAND DISPOSAL AREA
DRILL HOLE 84
LOCATION: AXIS OF PROPOSED DIKE
WEST SIDE OF AREA
TYPE OF SAMPLES: UND. CYL.
ELEVATION TOP OF HOLE = M.L.W.
DATE: OCTOBER 1949

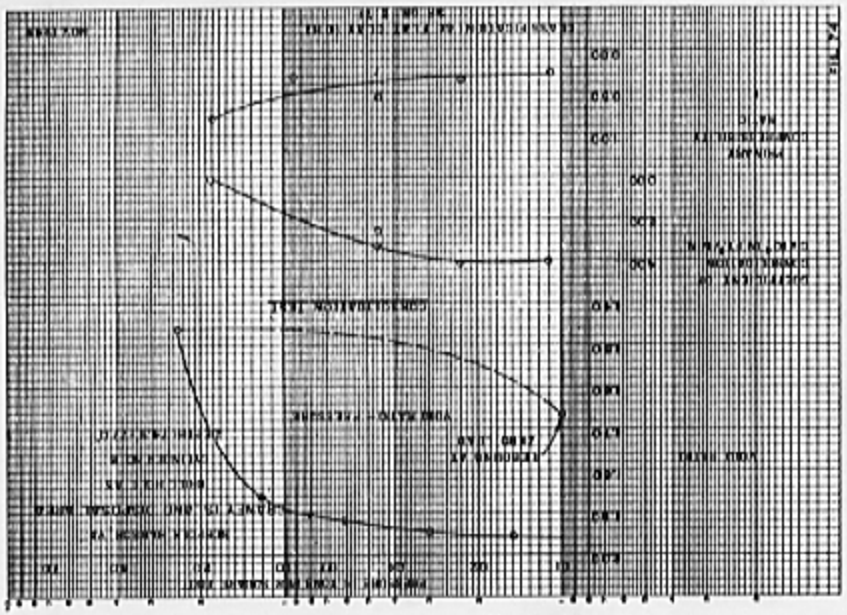
Exhibit I Sheet 19

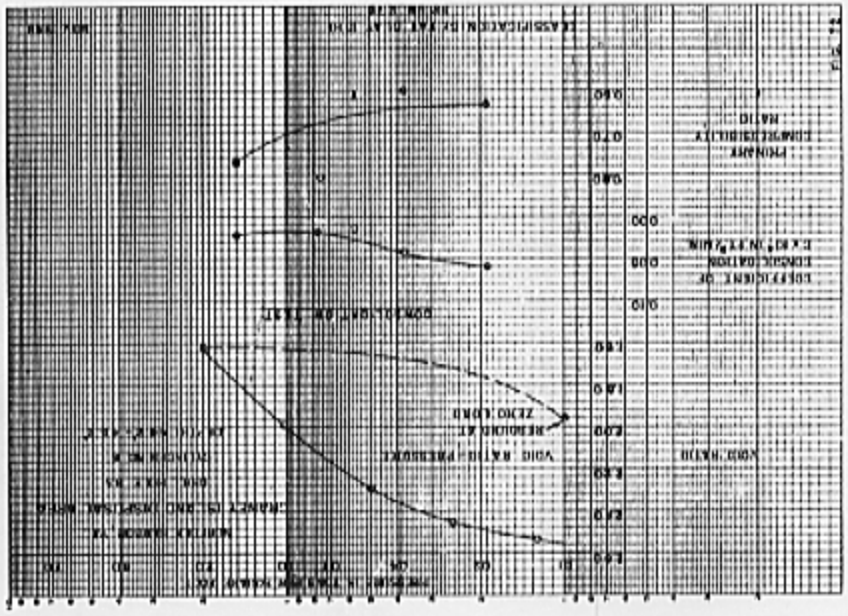
Exhibit I Sheet 20

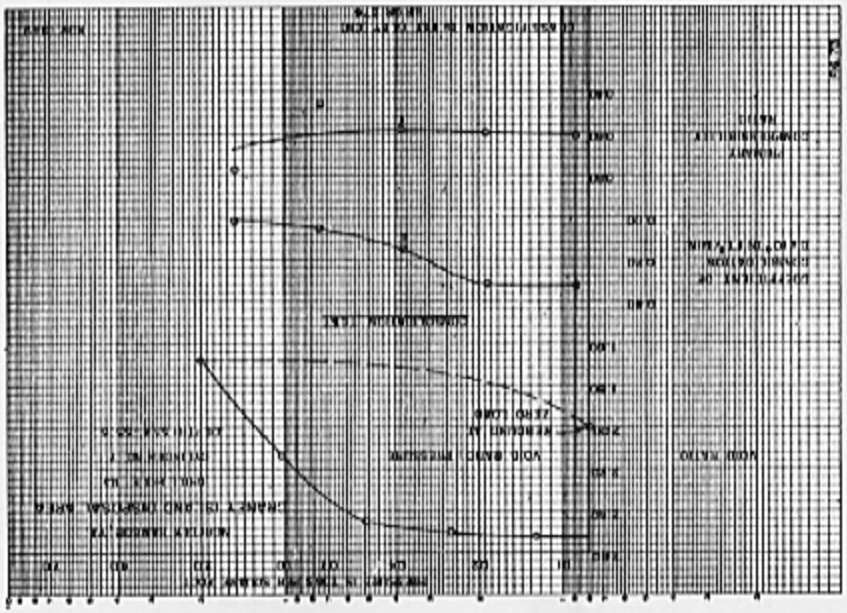
Exhibit I Sheet 21

Exhibit I Sheet 22

Exhibit I Sheet 24







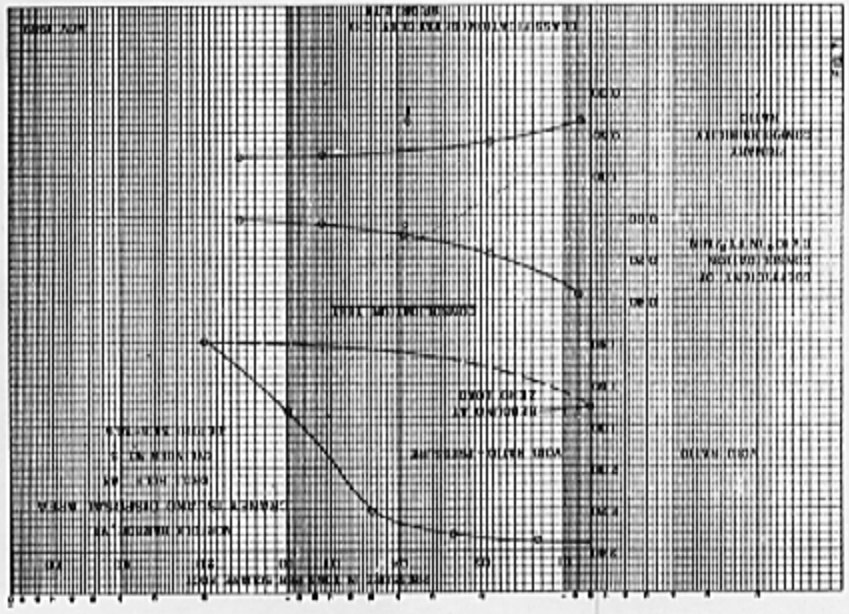
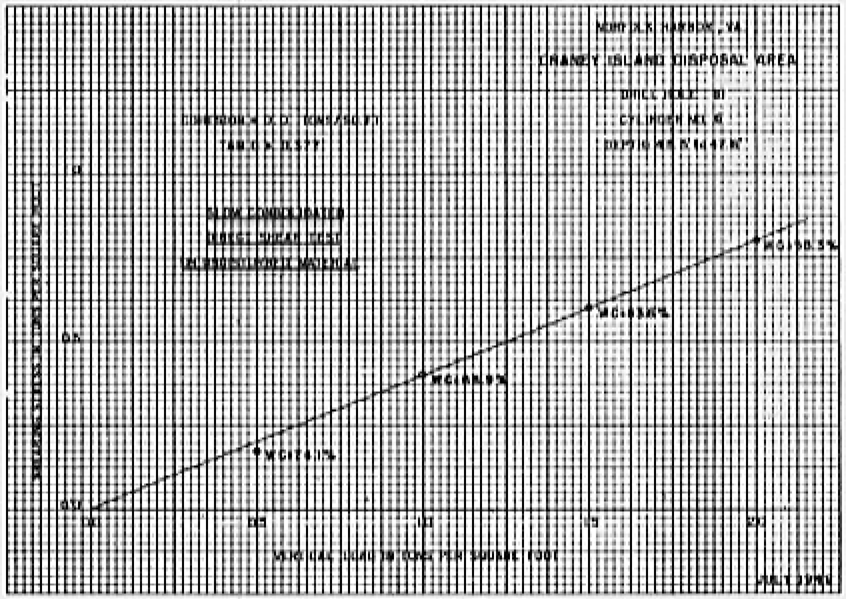
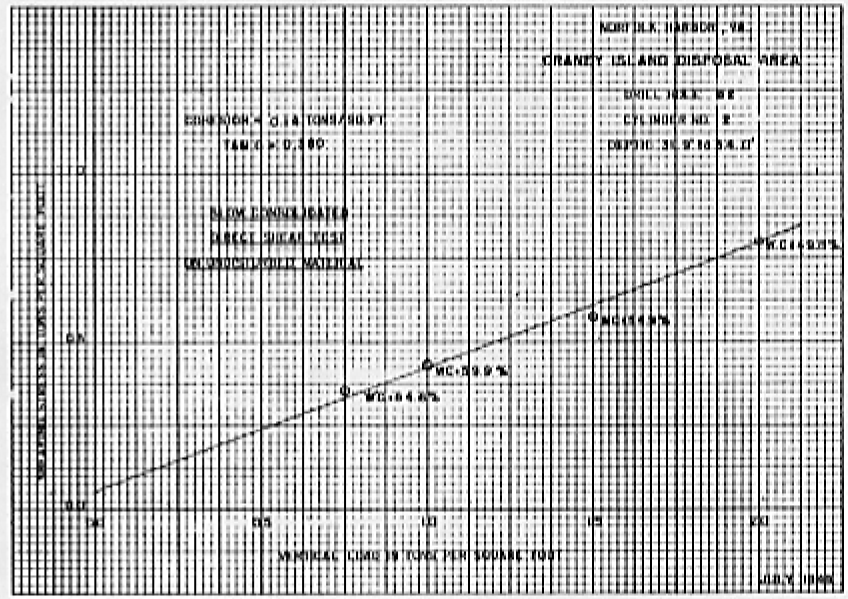
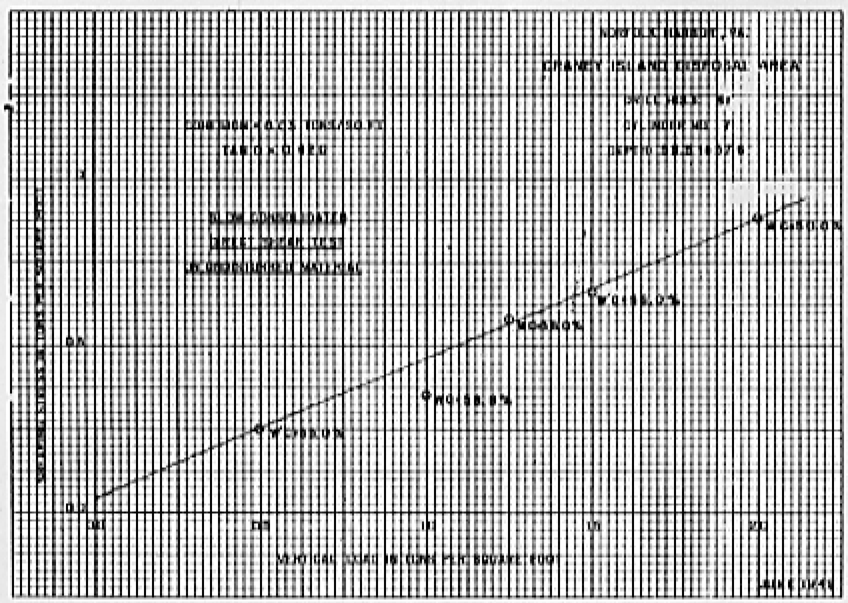


Exhibit I Sheet 25

Exhibit I Sheet 27







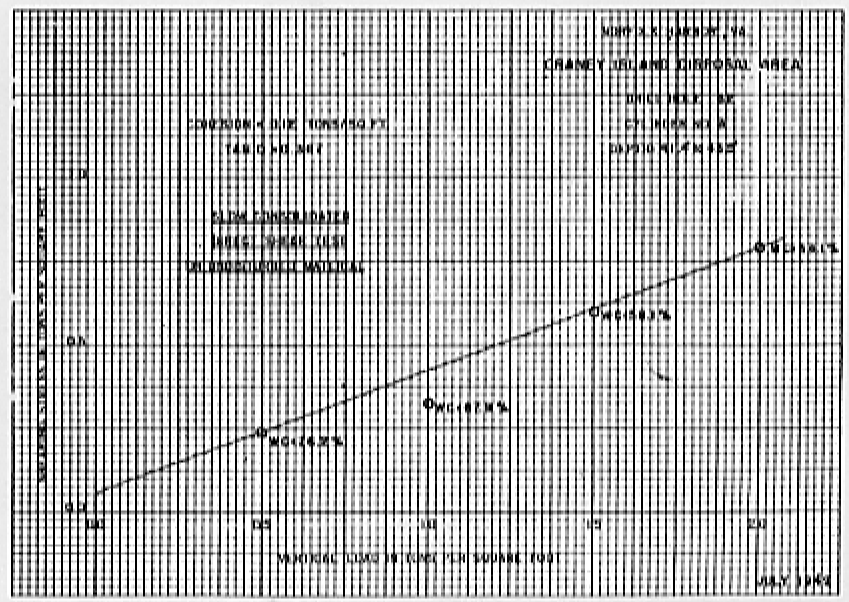
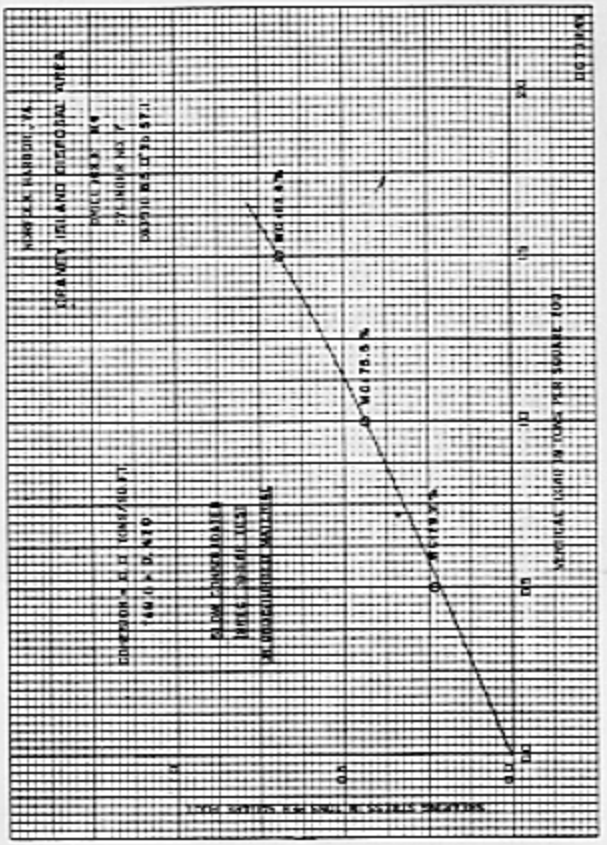


Exhibit I Sheet 28

Exhibit I Sheet 29

Exhibit I Sheet 30



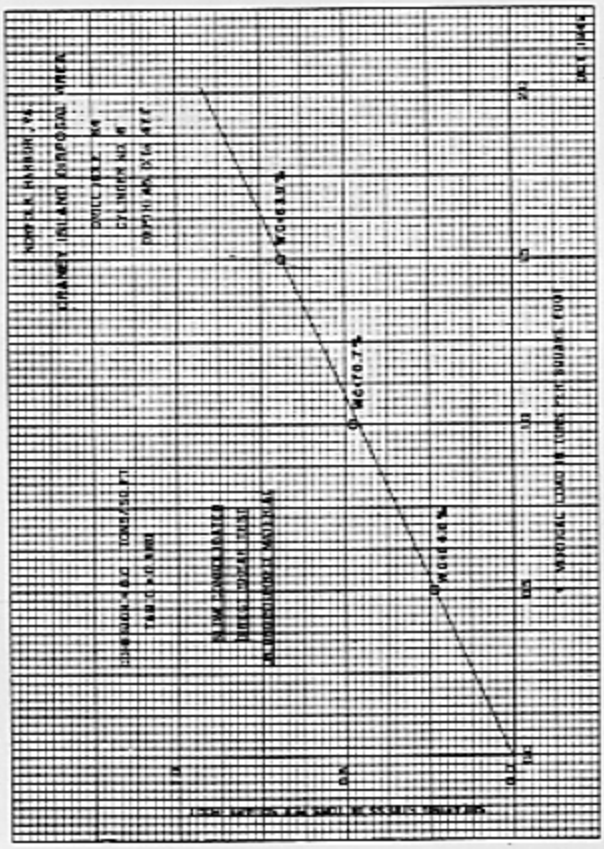
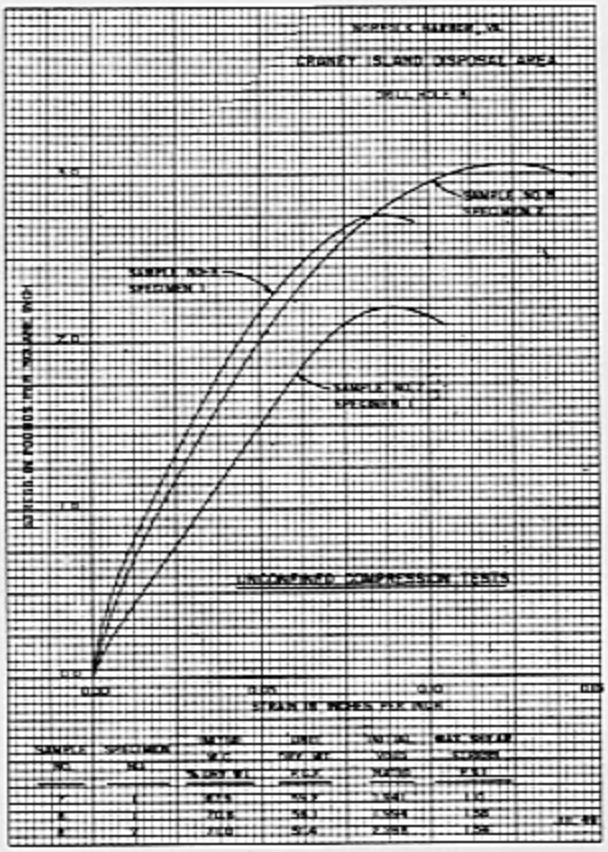
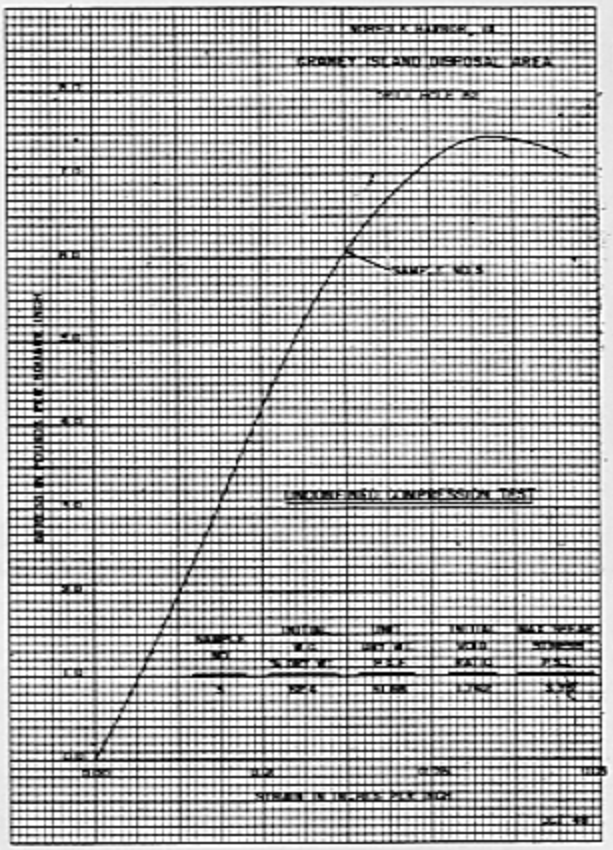
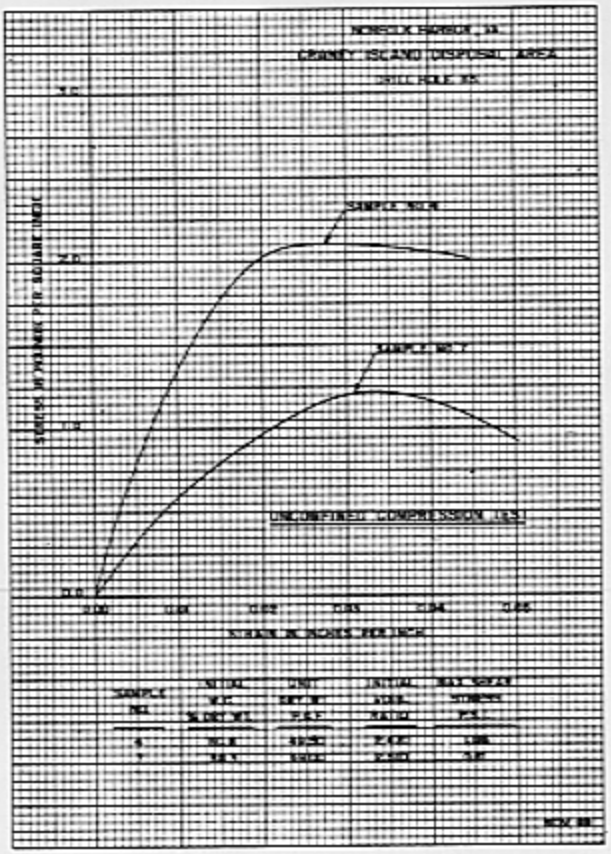
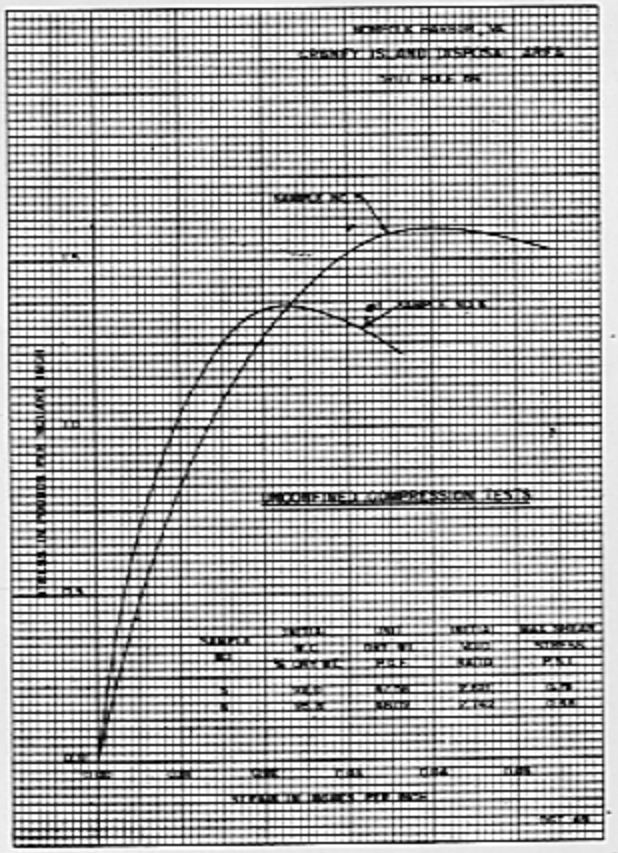


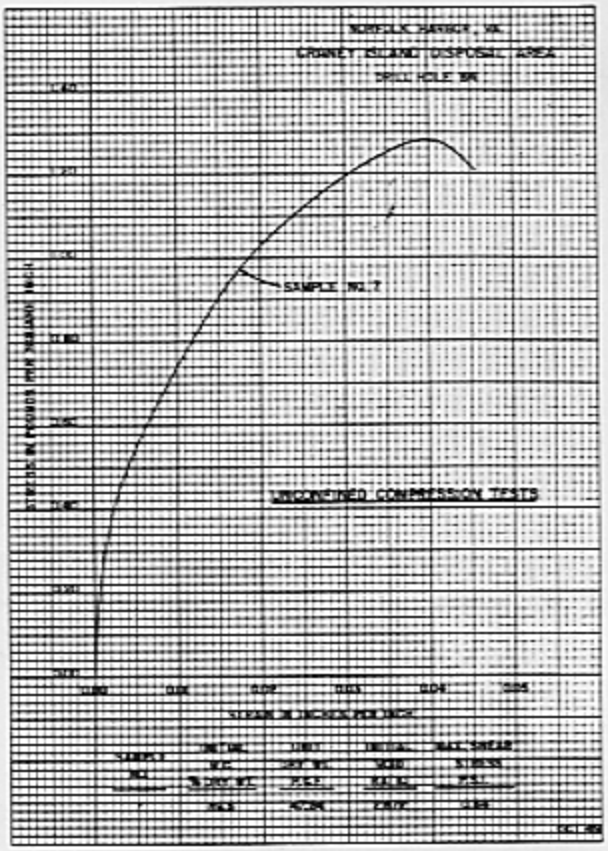
Exhibit I Sheet 33

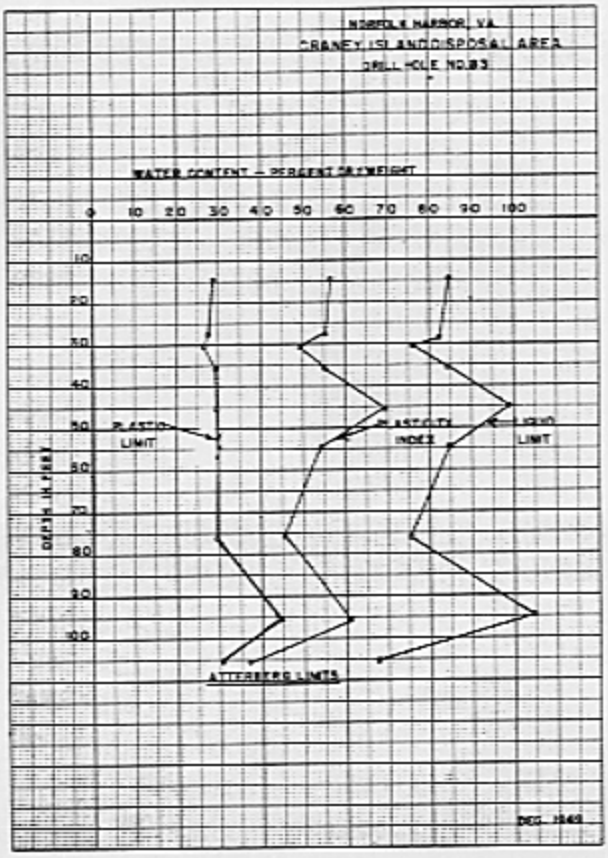

NORFOLK HARBOR, VA.
CRANEY ISLAND DISPOSAL AREA
DRILL HOLE 6
SAMPLE NO.6
SPECIMEN 2
SAMPLE NO.6
SPECIMEN 1
SAMPLE NO.6
SPECIMEN 3
UNCONFINED COMPRESSION TESTS
STRAIN IN INCHES PER INCH

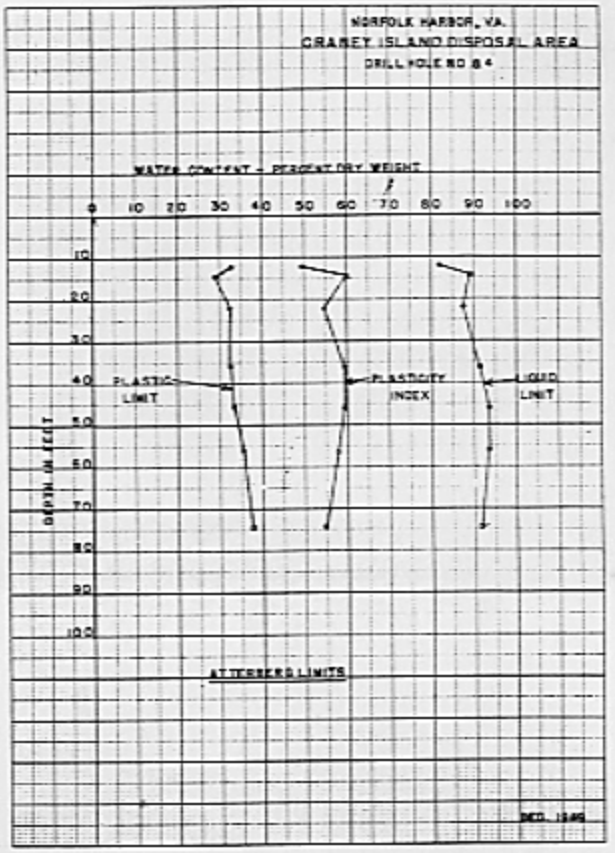

NORFOLK HARBOR, VA.
CRANEY ISLAND DISPOSAL AREA
DRILL HOLE 6C
UNCONFINED COMPRESSION TEST
STRAIN IN INCHES PER INCH

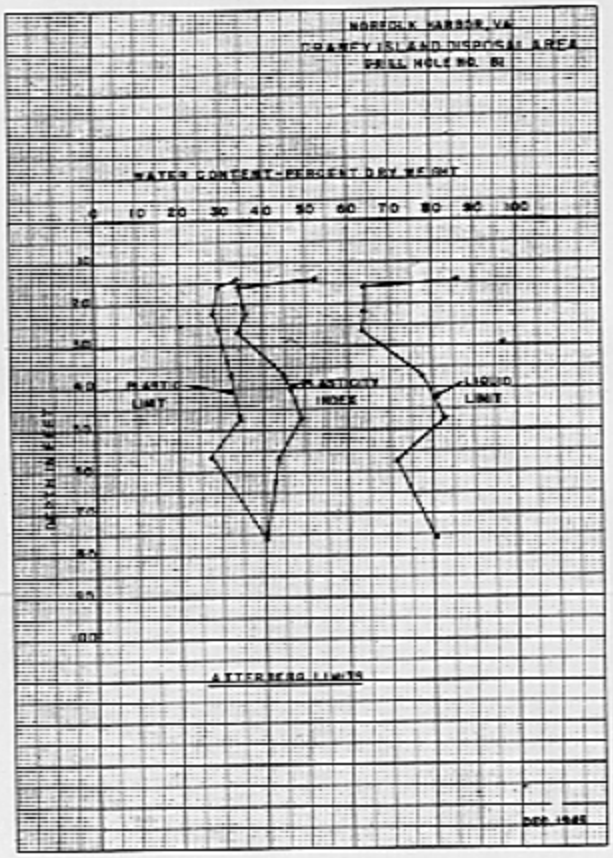

NORFOLK HARBOR, VA.
CRANEY ISLAND DISPOSAL AREA
DRILL HOLE 7C
SAMPLE NO.7
SAMPLE NO.7
UNCONFINED COMPRESSION TEST
STRAIN IN INCHES PER INCH

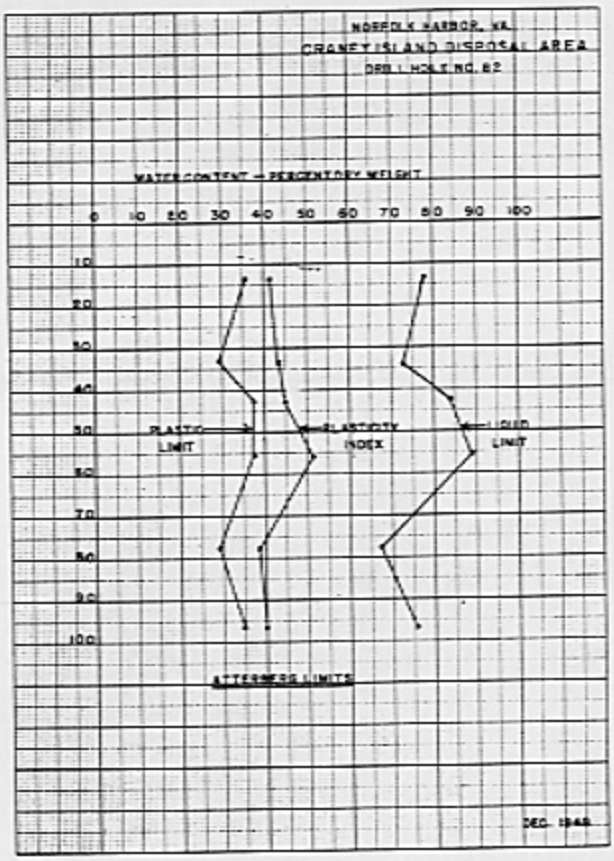

NORFOLK HARBOR, VA.
CRANEY ISLAND DISPOSAL AREA
DRILL HOLE 7C
SAMPLE NO.7
SAMPLE NO.8
UNCONFINED COMPRESSION TESTS
STRAIN IN INCHES PER INCH

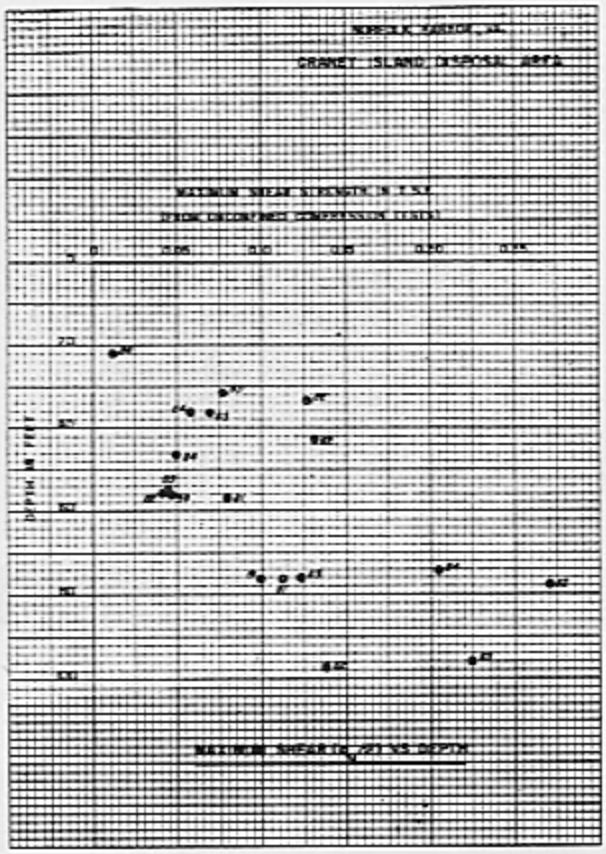

NORFOLK HARBOR, VA.
CRANEY ISLAND DISPOSAL AREA
SAMPLE NO. 7
UNCONFINED COMPRESSION TESTS

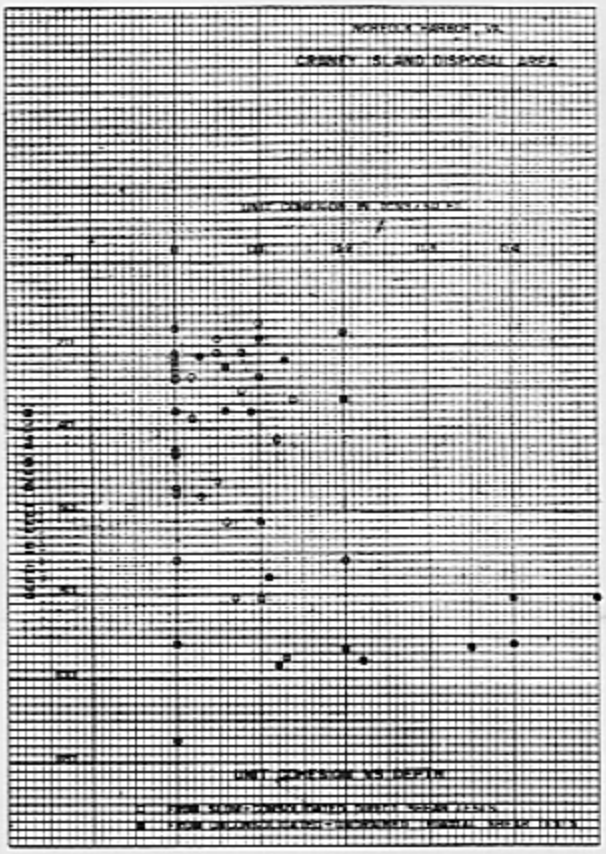

NORFOLK HARBOR, VA.
CRANEY ISLAND DISPOSAL AREA
DRILL HOLE NO. B3
WATER CONTENT - PERCENT DRY WEIGHT
0 10 20 30 40 50 60 70 80 90 100
DEPTH IN FEET
PLASTIC LIMIT
PLASTICITY INDEX
LIQUID LIMIT
ATTERBERG LIMITS
DEC. 1949

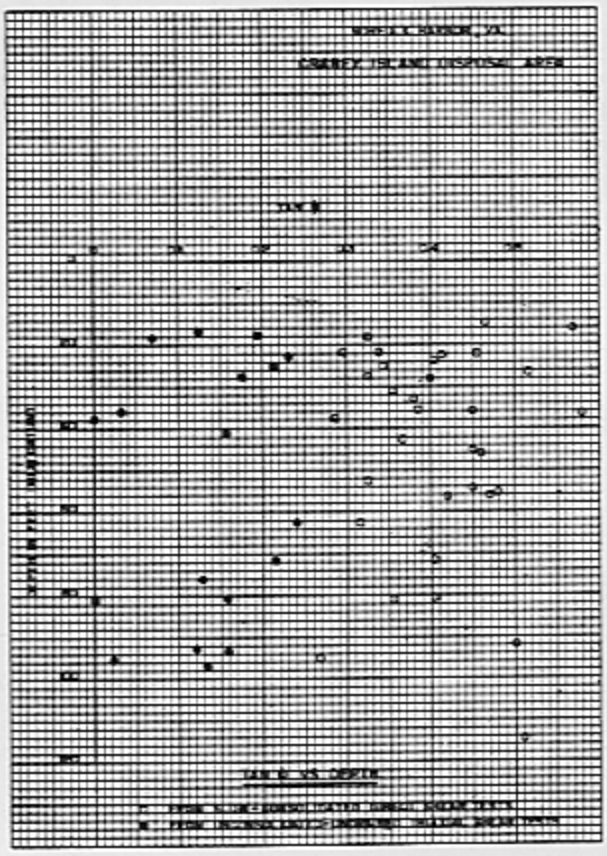

NORFOLK HARBOR, VA.
CRANEY ISLAND DISPOSAL AREA
DRILL HOLE NO. B4
WATER CONTENT - PERCENT DRY WEIGHT
0 10 20 30 40 50 60 70 80 90 100
DEPTH IN FEET
PLASTIC LIMIT
PLASTICITY INDEX
LIQUID LIMIT
ATTERBERG LIMITS
DEC. 1949


NORFOLK HARBOR, VA.
CRANEY ISLAND DISPOSAL AREA
DRILL HOLE NO. B2
WATER CONTENT - PERCENT DRY WEIGHT
0 10 20 30 40 50 60 70 80 90 100
DEPTH IN FEET
PLASTIC LIMIT
PLASTICITY INDEX
LIQUID LIMIT
ATTERBERG LIMITS
DEC. 1949


NORFOLK HARBOR, VA.
CRANEY ISLAND DISPOSAL AREA
DRILL HOLE NO. B2
WATER CONTENT - PERCENT DRY WEIGHT
0 10 20 30 40 50 60 70 80 90 100
PLASTIC LIMIT
PLASTICITY INDEX
LIQUID LIMIT
ATTERBERG LIMITS
DEC. 1949







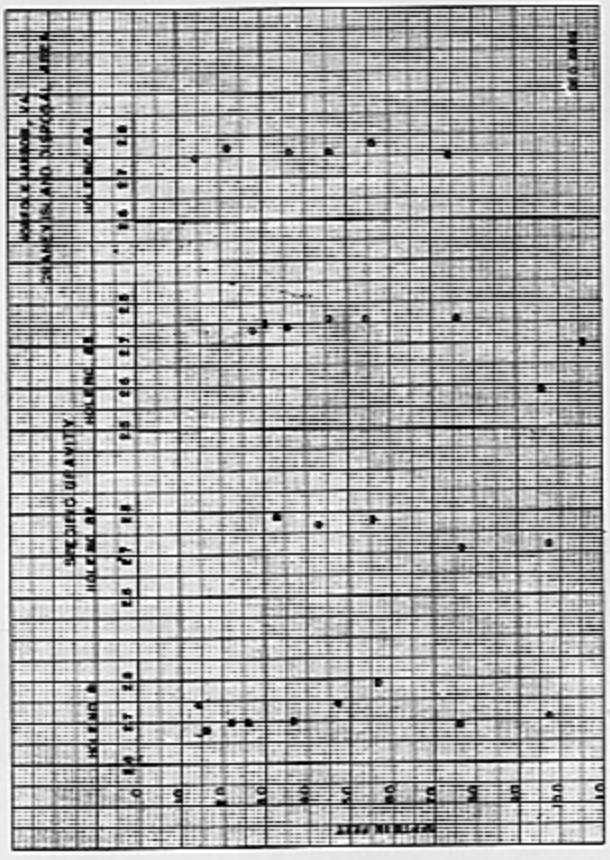


Exhibit I Sheet 38

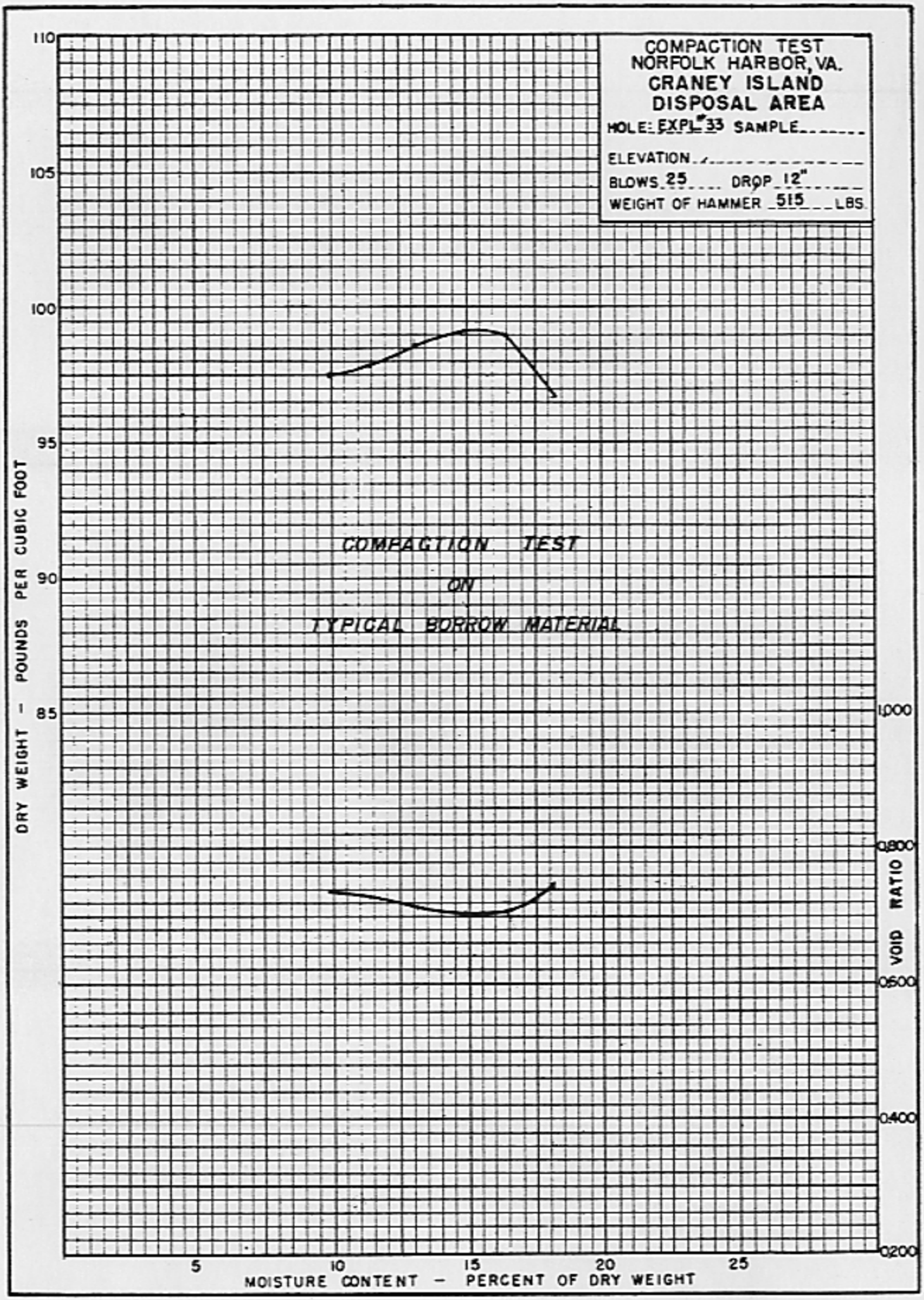
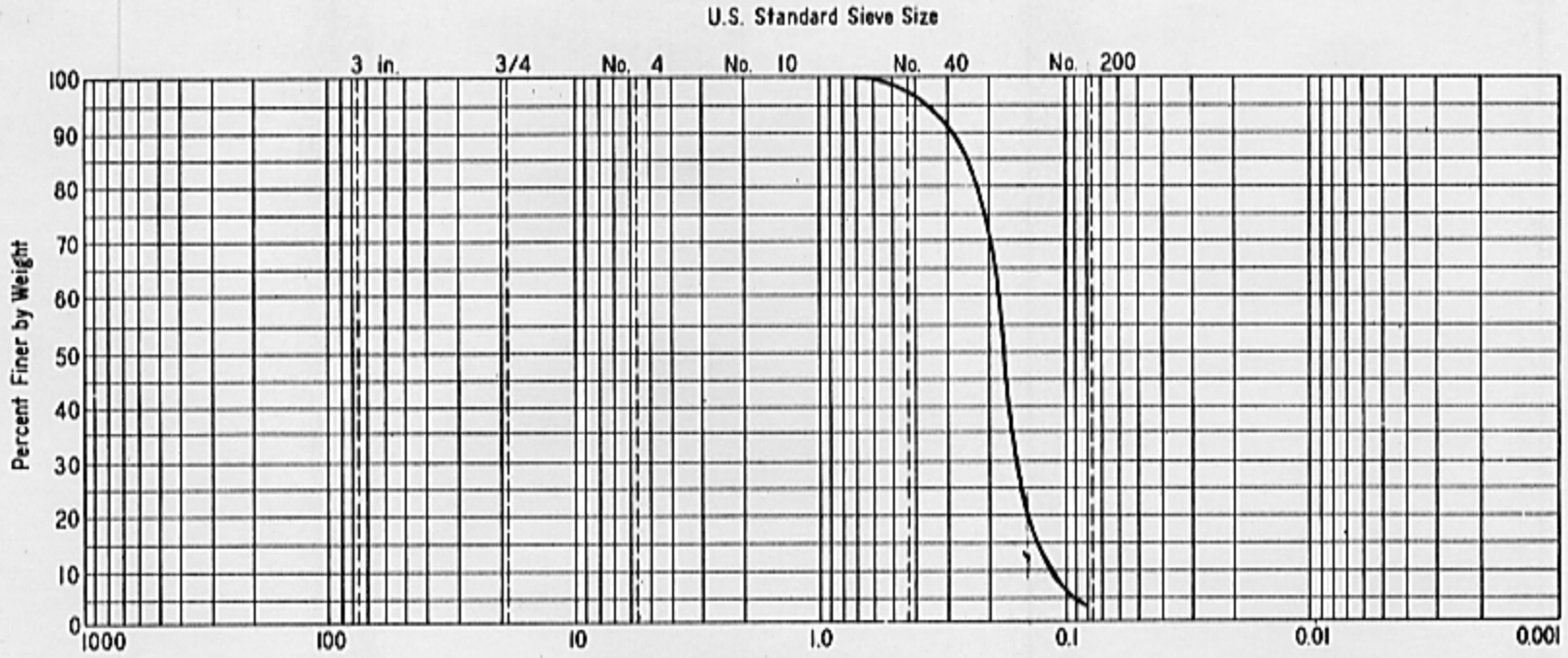


Exhibit I – Sheet 39



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

Number	Natural % Moisture	LL	PL	PI	Classification	Remarks
1					*Fine to Medium Sand*	

NORFOLK HARBOR, VA.
CRANEY ISLAND DISPOSAL AREA
DRILL HOLE 33

TYPICAL BORROW MATERIAL

DATE: 25 FEB. 1949

Exhibit I - Sheet 40

NORFOLK HARBOR, VIRGINIA

CRANEY ISLAND DISPOSAL AREA

EXHIBIT II-SCOPE OF LABORATORY TESTING PROGRAM

TYPE OF TEST	DRILL HOLE 22								DRILL HOLE 23							DRILL HOLE 24				
	Cylinder No.								Cylinder No.							Cylinder No.				
	3	5	6	9	10	11	14	18	3	6	9	10	11	15	17	4	8	9	11	14
Mechanical Analysis	X	X		X	X	X		X	X	X		X		X	X	X		X		X
Unit Dry Weight	X	X		X	X		X			X	X	X		X		X				X
Natural Water Content	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Specific Gravity	X	X	X		X			X		X		X			X	X		X		X
Atterberg Limits	X				X			X		X		X			X	X				X
Permeability (Direct)	X				X			X												
Direct Shear	X				X			X		X		X			X	X			X	X
Triaxial Shear	X			X			X			X	X	X		X	X	X				X
P-e Relationship	X			X				X		X		X			X	X		X		X
P-k Relationship	X			X				X		X		X			X	X		X		X
P-C Relationship	X			X				X		X		X			X	X		X		X
P-γ Relationship																				
Unconfined Compression																				

TYPE OF TEST	DRILL HOLE 25							DRILL HOLE 26					DRILL HOLE 01								
	Cylinder No.							Cylinder No.					Cylinder No.								
	2	3	5	7	9	13	14	1	2	6	8	12	1	2	3	4	5	6	7	8	9
Mechanical Analysis	X	X	X	X		X	X		X	X		X	X	X	X	X	X	X	X	X	X
Unit Dry Weight			X	X	X	X	X		X	X		X	X	X	X	X	X	X	X	X	X
Natural Water Content	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Specific Gravity			X		X	X	X		X	X		X	X	X	X	X	X	X	X	X	X
Atterberg Limits			X		X	X	X		X	X		X	X	X	X	X	X	X	X	X	(a)
Permeability (Direct)																					
Direct Shear			X	X		X	X	X		X		X		X	X	X	X	X	X		
Triaxial Shear			X	X	X	X	X		X	X		X									
P-e Relationship			X		X	X	X		X	X		X	X	X	X	X	X	X	X	X	X
P-k Relationship			X		X	X	X		X	X		X									
P-C Relationship			X		X	X	X		X	X		X	X	X	X	X	X	X	X	X	X
P-γ Relationship												X	X	X	X	X	X	X	X	X	X
Unconfined Compression																			X	X	

TYPE OF TEST	DRILL HOLE 02						DRILL HOLE 03										DRILL HOLE 04						
	Cylinder No.						Cylinder No.										Cylinder No.						
	1	2	3	4	5	6	1	2	3	4	5	6	7	8	9	10	1	2	3	5	6	7	8
Mechanical Analysis	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Unit Dry Weight		X	X	X	X	X			X	X	X	X	X	X	X	X		X	X	X	X	X	X
Natural Water Content	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Specific Gravity		X	X	X	X	X			X	X	X	X	X	X	X	X		X	X	X	X	X	X
Atterberg Limits	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Permeability (Direct)																							
Direct Shear		X	X	X					X	X	X	X	X						X	X	X	X	
Triaxial Shear						(b)					(b)			(b)	(b)								
P-e Relationship		X	X	X	X	X			X	X	X	X	X	X	X	X		X	X	X	X	X	X
P-k Relationship																							
P-C Relationship		X	X	X	X	X			X	X	X	X	X	X	X	X		X	X	X	X	X	X
P-γ Relationship		X	X	X	X	X			X	X	X	X	X	X	X	X		X	X	X	X	X	X
Unconfined Compression		X	X	X	X					X			X						X	X	X	X	X

(a) = Non Plastic

(b) = Includes stress-strain curves for principal planes from Mohr Diagram

Exhibit II

NORFOLK HARBOR, VIRGINIA
CRANEY ISLAND DISPOSAL AREA

EXHIBIT III - SUMMARY OF LABORATORY TESTS OF UNDISTURBED SOIL SAMPLES

LOCATION OF SAMPLE				SOIL CLASSIFICATION						PROPERTIES OF UNDISTURBED SOIL																		SOIL ZONE ASSIGNED BY NORFOLK DISTRICT
		ELEVATION (M.L.W. DATUM)					ATTERBERG LIMITS					DIRECT SHEAR TEST		TRIAXIAL SHEAR TEST					CONSOLIDATION TEST				UNCONFINED COMPRESSION TEST					
																AVERAGE VALUES												
DRILL HOLE	CYLINDER SPECIMEN NO.	FROM	TO	DESCRIPTION	SYMBOL	SPECIFIC GRAVITY	L.L. %	P.L. %	P.I.	NATURAL WATER CONTENT % Dry Wt	NATURAL DRY DENSITY p.c.f.	COHESION T.s.f.	TAN φ	COHESION T.s.f.	TAN φ	e_o	W.C. % Dry Wt	DRY D. p.c.f.	FINAL W.C. % Dry Wt	e_o	e_f	e_{min}	MAXIMUM SHEAR p.s.f.	e_o	WATER CONTENT % Dry Wt	DRY DENSITY p.c.f.		
52	3	-21.4	-23.5	Marine Clay with Embedded Shells		2.75	90.5	25.7	64.8	86.3		0	0.414	0.03	0.231			60.2		2.406	1.506							A
	5	-25.6	-27.7	-do-						84.0																		A
	6	-27.7	-29.8	-do-		2.75				78.3																		A
	8	-36.3	-38.8	-do-						84.8																		B
	10	-40.8	-43.3	-do-		2.70	75.5	31.4	46.1	80.0		0.06	0.318	0.10	0.240			48.1		2.567	1.625							D
	11	-71.1	-73.3	-do-						78.7																		D
	14	-81	-84.2	-do-						77.3				0.33	0.168			55.1										D
	15	-94.8	-95.8	-do-		2.67	66.4	34.6	31.8	75.6		0.13	0.268							2.041	1.478							D
53	3	-14.8	-16.9	Marine Clay with Embedded Shells						120.6																		A
	6	-20.7	-22.8	-do-		2.75	81.6	30.9	50.7	94.4		0.06	0.286							2.658	1.500							A
	8	-47.8	-50.0	-do-						88.5								49.5										A
	10	-56.7	-58.8	-do-		2.74	86.0	38.5	47.7	90.8		0.03	0.267	0.80	0			48.4		2.61	1.561							B
	11	-50.3	-51.0	-do-																								B
	13	-91.5	-93.5	Marine Clay Some Silt						79.6				0.20	0.150			62.8										C
	17	-95.5	-97.5	Sandy Silt, Little Clay		2.68	41.6	26.6	15.0	41.4		0	0.510							1.299	—							C
54	4	-17.2	-19.3	Marine Clay with Embedded Shells		2.80	52.4	29.7	22.7	94.7		0.05	0.355	0.10	0.070			54.0		2.571	1.317							A
	6	-25.8	-27.6	-do-						104.5																		A
	9	-56.1	-54.2	-do-		2.80				92.5										2.454	1.585							B
	11	-54.6	-55.7	-do-						89.5		0.05	0.355															B
	14	-78.5	-80.0	Marine Clay, Some Silt		2.75	57.4	32.8	24.6	75.0		0.10	0.454	0.40	0			58.1		2.012	1.428							C
55	3	-11.6	-13.6	Marine Clay with Embedded Shells						93.3																		A
	5	-15.6	-16.7	-do-						89.8																		A
	6	-22.2	-24.4	-do-		2.70	66.8	27.9	38.9			0	0.404	0.15	0.194			51.5		2.475	1.356							A
	7	-26.6	-28.6	-do-						90.5		0.08	0.388	0.10	0.170			47.8										A
	8	-40.0	-42.1	-do-		2.75	81.6	31.6	50.5	86.7										2.381	1.324							B
	13	-79.6	-81.7	-do-		2.67	67.4	31.8	35.9	76.3		0.07	0.404	0.30	0.150			57.6		2.054	1.432							C
	14	-89.7	-90.8	Clayey Silt, Traces of Fine Sand		2.75	48.8	30.0	18.8	58.8		0	0.600	0.10	0.150			69.8		1.418	1.105							D
56	1	-10.6	-15.6	Marine Clay with Embedded Shells								0.10	0.466															A
	3	-16.6	-17.7	-do-		2.70	43.6	25.6	17.6	76.8				0.20	0.135			65.5		2.153	1.106							A
	6	-55.9	-58.0	-do-		2.75	80.1	38.5	41.6	87.4		0	0.344	0.06	0.215			45.2		2.390	1.378							A
	8	-66.4	-68.5	-do-																								B
	12	-79.7	-78.8	-do-		2.78	47.6	26.9	20.4	58.8		0	0.404	0.20	0.215			57.6		1.622	1.128							C
61	1	-8.1	-10.2	Gray Fat Organic Clay (Marine Deposit)	OH	2.74	96.4	35.1	60.5	106.0	41.3								56.4	3.150	1.676	1.492						A
	2	-10.2	-15.9	Gray Fat Clay (Marine Deposit)	CH	2.68	84.0	29.4	54.6	75.7	56.3	0	0.570						43.5	1.966	1.188	1.080						A
	3	-21.0	-23.1	-do-	CH	2.70	88.0	35.1	52.9	74.7	54.6	0	0.488						46.2	2.064	1.205	1.069						A
	4	-25.8	-29.9	-do-	CH	2.70	62.5	29.3	34.2	72.8	56.3	0	0.517						49.8	1.992	1.335	1.178						A
	5	-35.8	-37.8	-do-	CH	2.70	77.7	32.6	45.1	85.1	47.1	0	0.560						65.4	2.566	1.748	1.418						B
	6	-45.8	-47.8	-do-	CH	2.74	85.5	34.8	48.1	84.7	46.9	0	0.577						71.2	2.046	1.871	1.608						B
	7	-65.8	-67.8	-do-	OH	2.70	71.4	27.6	43.8	77.4	55.5	0.08	0.480						65.8	2.257	1.606	1.502	1.10	2.041	67.8	56.8		B
	8	-76.0	-77.1	Gray Fat Organic Clay (Marine Deposit)	OH	2.80	90.5	40.6	40.0	85.2	51.9								59.1	2.236	1.645	1.565	1.64	2.290	71.0	61.4		C
	9	-95.9	-98.2	Gray Sandy Silt (Marine Deposit)	ML	2.72	NP	NP	NP	21.4	103.8								18.4	0.634	0.556	0.556						D
62	1	-10.8	-11.7	Gray Fat Organic Clay (Marine Deposit)	OH		78.1	36.0	41.6	73.6																		A
	2	-21.8	-24.0	Gray Fat Clay (Marine Deposit)	CH	2.75	73.6	28.7	43.9	80.5	52.7	0.14	0.380						59.8	2.287	1.561	1.369	1.75	2.135	73.1	55.5		B
	3	-41.4	-43.5	Gray Fat Organic Clay (Marine Deposit)	OH	2.77	83.8	36.6	46.2	83.6	51.9	0.12	0.367						64.1	2.272	1.721	1.412	1.80	2.183	78.4	56.4		B
	4	-64.4	-66.5	Gray Fat Clay (Marine Deposit)	OH	2.70	89.0	37.5	51.5	78.4	55.3	0	0.46						66.4	2.237	1.686	1.605	0.86	2.284	77.2	52.7		B
	5	-78.8	-78.9	-do-	CH	2.71	67.7	29.5	38.2	80.3	54.8								53.8	1.834	1.484	1.276	2.75	1.748	62.4	61.7		C
	6	-95.7	-97.8	Gray Fat Organic Clay (Marine Deposit)	OH	2.78	76.6	36.7	39.9	76.0	64.1			0.16	0.133	2.042	71.0	55.8	76.8	2.150	1.908	1.745	1.80	2.077	70.6	56.4		D
63	1	-10.4	-12.5	Gray Fat Clay (approx. 60% shells)	OH					48.8																		A
	2	-12.6	-16.7	-do-	CH		84.4	28.2	56.2	49.9																		A
	3	-26.8	-28.9	Gray Fat Clay	CH	2.75	82.8	27.3	55.5	88.2	49.9	0	0.400						59.2	2.432	1.889	1.387						A
	4	-29.7	-31.8	-do-	CH	2.75	76.3	26.7	49.6	88.7	51.6	0.08	0.355						56.9	2.330	1.660	1.384	1.06	2.67	90.8	48.5		B
	5	-35.8	-38.0	-do-	CH	2.74	84.4	28.1	56.3	86.7	50.8	0.09	0.365	0.08	0.032	2.025	64.5	48.7	63.5	2.308	1.716	1.407	0.88	2.510	85.0	61.6		B
	6	-44.8	-46.8	-do-	CH	2.76	88.1	29.9	58.2	98.0	47.7	0	0.450						68.8	2.510	1.856	1.851						B
	7	-59.4	-66.5	-do-	CH	2.75	84.8	30.4	54.2	91.9	49.5	0	0.480						71.8	2.555	1.887	1.665	0.81	2.510	49.0	66.5		B
	8	-74.8	-77.0	-do-	CH	2.71	75.2	26.5	48.4	73.2	57.4			0.11	0.129	1.776	43.8	61.0	82.1	1.988	1.668	1.468	1.70	1.705	62.8	62.5		C
	9	-94.8	-96.8	Gray Fat Clay, high organic content	CH	2.66	104.6	44.1	60.7	88.8	48.0			0.23	0.088	1.880	70.5	49.6	87.7	2.387	2.298	2.018	8.10	1.890	80.4	70.2		D
	10	-104.4	-108.8	Gray Fat Clay	CH	2.70	67.5	30.7	37.1	58.3	65.4								53.8	1.575	1.454	1.308						D
64	1	-14.1	-13.8	Gray Fat Clay (Marine Deposit)	CH		92.0	36.6	49.5	141.8									56.9	3.365	1.605	1.851						A
	2	-18.7	-18.5	-do-	CH	2.75	89.2	28.8	60.0	128.1	36.3								64.1	2.671	1.768	1.506	0.18	2.848	56.8	44.8		A
	3	-20.8	-22.7	-do-	CH	2.77	87.4	32.4	58.0	101.8	44.6	0.05	0.558						66.2	2.450	1.685	1.582	0.79	2.581	68.0	47.8		A
	5	-34.8	-37.0	-do-	CH	2.76	81.7	32.2	49.5	88.1	49.5	0	0.480						68.6	2.465	1.948	1.618	0.88	2.748	95.8	48.0		B
	6	-48.0	-47.1	-do-	CH	2.76	85.4	33.7	56.7	88.8	49.5	0	0.460						70.8	2.741	1.972	1.828	0.84	2.672	89.5	47.2		B
	7	-56.0	-57.1	-do-	CH	2.75	83.8	36.8	57.8	95.7	46.4	0	0.430															B
	8	-75.1	-76.8	-do-	CH	2.75	86.0	37.8	54.8	84.3	47.3								78.8	2.810	2.160	1.843	2.08	2.410	67.3	50.8		C

CORPS OF ENGINEERS | U S ARMY

SECTION	SAND & RIPRAP VOLUME	d_1	W_1	MARINE CLAY VOLUME	d_2	W_2	WATER VOLUME	d_3	W_3	VOLUME	d_4	W_4	TOTAL W_t	HYDROSTATIC UPLIFT Σ (H₁+H₂)·L	d_0	E_0	LATERAL HYDROSTATIC PRESSURES E_1	d_0	E	E_2	d_0	E_0	$E_1 - E_2$	φ DEGREES	TAN φ	NORMAL N	N·TAN φ	COHESION c	τ	τ·c	TANGENTIAL +T	TANGENTIAL −T	ΣT
1	740	.060	37.0	430	.048	21.9							89	110+40147+1840	.0312	49										-	-	.018	43	7.74	53		
2	640	*	38.8	1780		84.8							117	140+69130+2780		88									0.061	3	0.18		59	9.00	69		
3	550	.060	21.7	2750		132.0	40	.0312	1.25				155	188+89148+3555		111										24	1.33		43	8.10	68		
4	500		18.8	3480		164	100		3.12				188	188+108142+4011		121										46	2.53		45	7.56	57		
5	340		14.9	3860		183	140		4.36				202	1102+101816+4385		134										60	3.66		41	7.38	33		
6	180		11.8	3990		191	200		6.25				206	1109+105140+4380		137										67	4.09		40	7.26	8		
7	120		7.4	3900		187	280		8.72				203	1140+103141+4407		138										60	3.66		41	7.38		33	
8	60		3.7	3650		175	330		10.3				188	1103+94142+4178		130										46	2.81		45	7.56		47	
9	40		2.5	3020		145	350		10.9				159	1184+78169+3740		117										24	1.33		43	7.86		61	
10	30		1.8	2190		104	380		11.8				117	1176+61148+3048		88										8	0		49	8.84		80	
11	11		0.7	871		41.7	404		12.6				55	1131+40138+1800		55										-	-		55	10.00		87	
																															388	308	80
																											20.42			88.10			

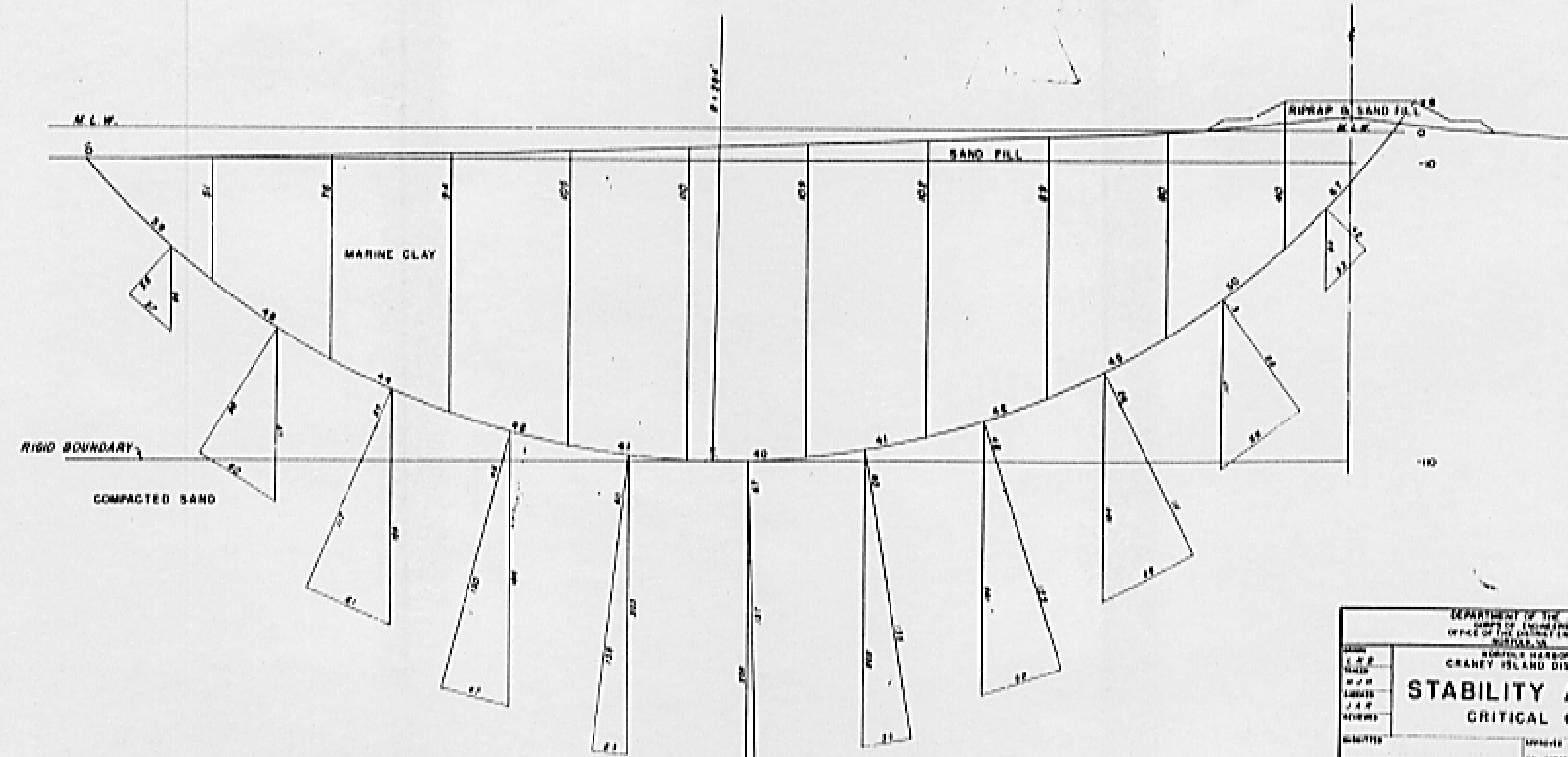
* Two unit weights indicated

INITIAL DATA

MATERIAL	DRY DENS. P.C.F.	SAT. DENS. P.C.F.	SHEAR φ deg.	COHESION T.S.F.
Marine Clay	77	98	9°30'	0.18
Sand	100	124	24°12'	0.10
Riprap	100	124	24°12'	0.00

FINAL DATA

FORCES RESISTING ΣN·TANφ	ΣL·C	DRIVING ΣT	STABILITY RATIO (ΣN·TANφ + ΣL·C) / ΣT
20.42	88.10	58	108.52/58 = 1.87



DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
OFFICE OF THE DISTRICT ENGINEER
NORFOLK, VA.

NORFOLK HARBOR, VIRGINIA
CRANEY ISLAND DISPOSAL AREA

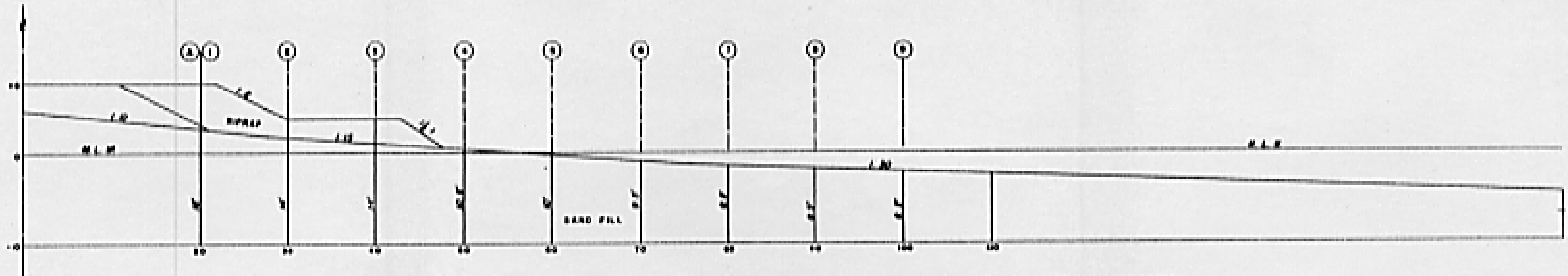
STABILITY ANALYSIS

CRITICAL CIRCLE

SCALES: SHOWN

SHEET | FILE

EXHIBIT IV

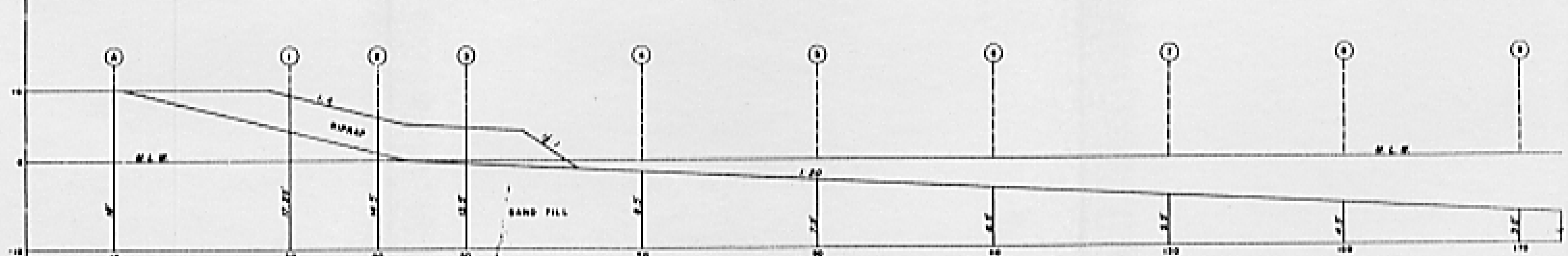


UNIT DRY WEIGHT OF SAND	W_d	100 pcf
UNIT SATURATED WEIGHT OF SAND	W_s	125 pcf
UNIT SUBMERGED WEIGHT OF SAND	W_b	62.6 pcf
ANGLE OF SHEARING RESISTANCE	ϕ	35°
UNIT COHESION MARINE CLAY	c	0.04 tsf

$K_p = \tan^2(45 + \phi/2)$

Vertical distances measured from mean low water datum

$P_a = \frac{1}{2} w H^2 1/K_p$						$P_p = \frac{1}{2} w H^2 K_p$						LENGTH	COHESION		$P_p + S$	STABILITY
Block	w pcf	H ft	H^2	$1/K_p$	P_a tons	Block	w pcf	H ft	H^2	K_p	P_p tons	L ft	c tsf	S = cL tons	tons	RATIO
A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]
						2	[illegible]	[illegible]	[illegible]		[illegible]	10		[illegible]	[illegible]	[illegible]
						3	[illegible]	[illegible]	[illegible]		[illegible]	20		[illegible]	[illegible]	[illegible]
						4	[illegible]	[illegible]	[illegible]		[illegible]	30		[illegible]	[illegible]	[illegible]
						5	[illegible]	[illegible]	[illegible]		[illegible]	40		[illegible]	[illegible]	[illegible]
						6		[illegible]	[illegible]		[illegible]	50		[illegible]	[illegible]	[illegible]
						7		[illegible]	[illegible]		[illegible]	60		[illegible]	[illegible]	[illegible]
						8		[illegible]	[illegible]		[illegible]	70		[illegible]	[illegible]	[illegible]
						9		[illegible]	[illegible]		[illegible]	80		[illegible]	[illegible]	[illegible]



UNIT DRY WEIGHT OF SAND	W_d	100 pcf
UNIT SATURATED WEIGHT OF SAND	W_s	125 pcf
UNIT SUBMERGED WEIGHT OF SAND	W_b	62.6 pcf
ANGLE OF SHEARING RESISTANCE	ϕ	35°
UNIT COHESION MARINE CLAY	c	0.04 tsf

$K_p = \tan^2(45 + \phi/2)$

Vertical distances measured from mean low water datum

$P_a = \frac{1}{2} w H^2 1/K_p$						$P_p = \frac{1}{2} w H^2 K_p$						LENGTH	COHESION		$P_p + S$	STABILITY
Block	w pcf	H ft	H^2	$1/K_p$	P_a tons	Block	w pcf	H ft	H^2	K_p	P_p tons	L ft	c tsf	S = cL tons	tons	RATIO
A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20	[illegible]	[illegible]	[illegible]	[illegible]
						2	[illegible]	[illegible]	[illegible]		[illegible]	30		[illegible]	[illegible]	[illegible]
						3	[illegible]	[illegible]	[illegible]		[illegible]	40		[illegible]	[illegible]	[illegible]
						4	[illegible]	[illegible]	[illegible]		[illegible]	60		[illegible]	[illegible]	[illegible]
						5		[illegible]	[illegible]		[illegible]	80		[illegible]	[illegible]	[illegible]
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						9		[illegible]	[illegible]		[illegible]	160		[illegible]	[illegible]	[illegible]

CORPS OF ENGINEERS
U.S. ARMY

NORFOLK HARBOR, VIRGINIA
CRANEY ISLAND DISPOSAL AREA

STABILITY ANALYSIS
SLIDING BLOCK METHOD

EXHIBIT XI

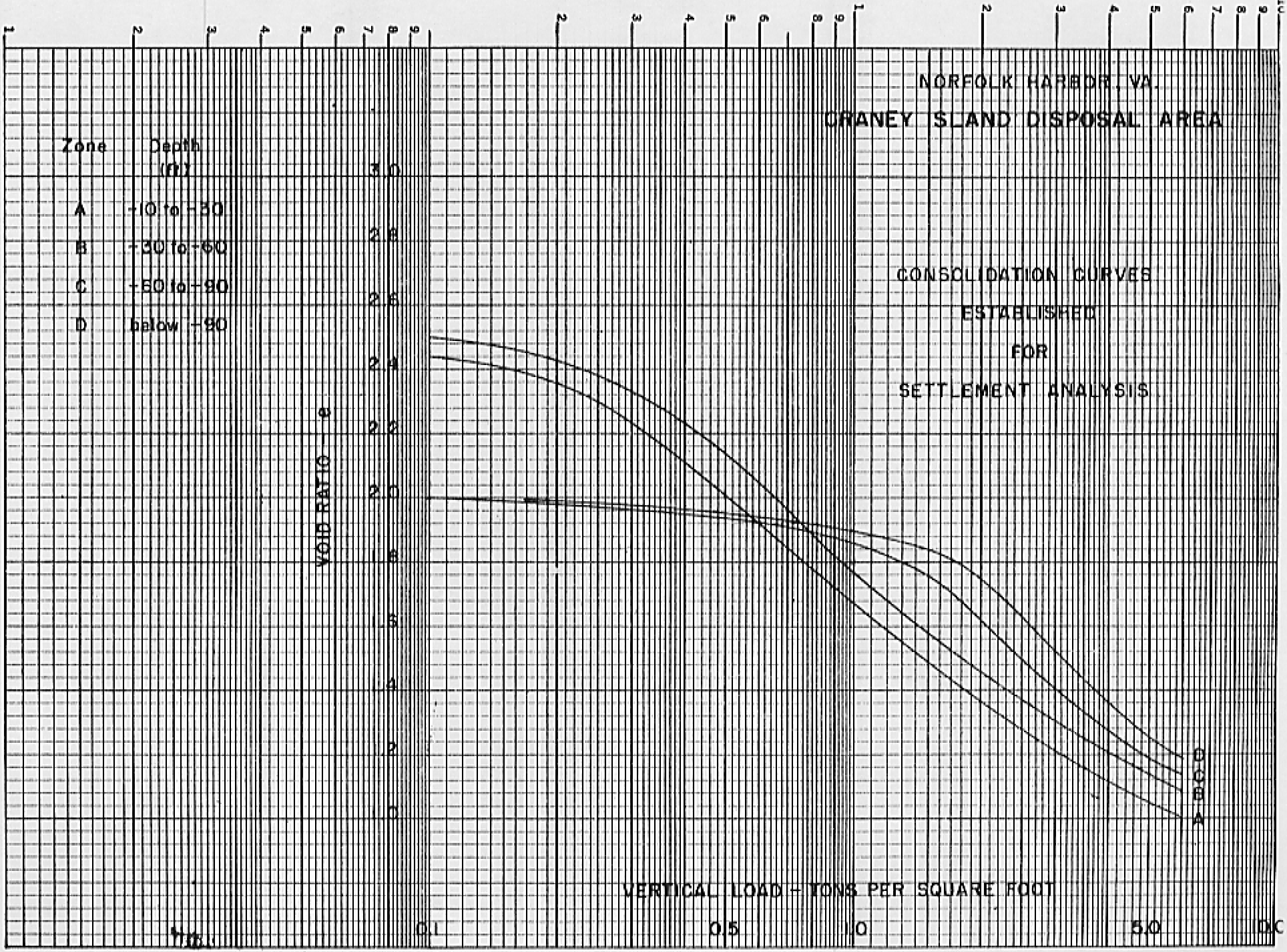
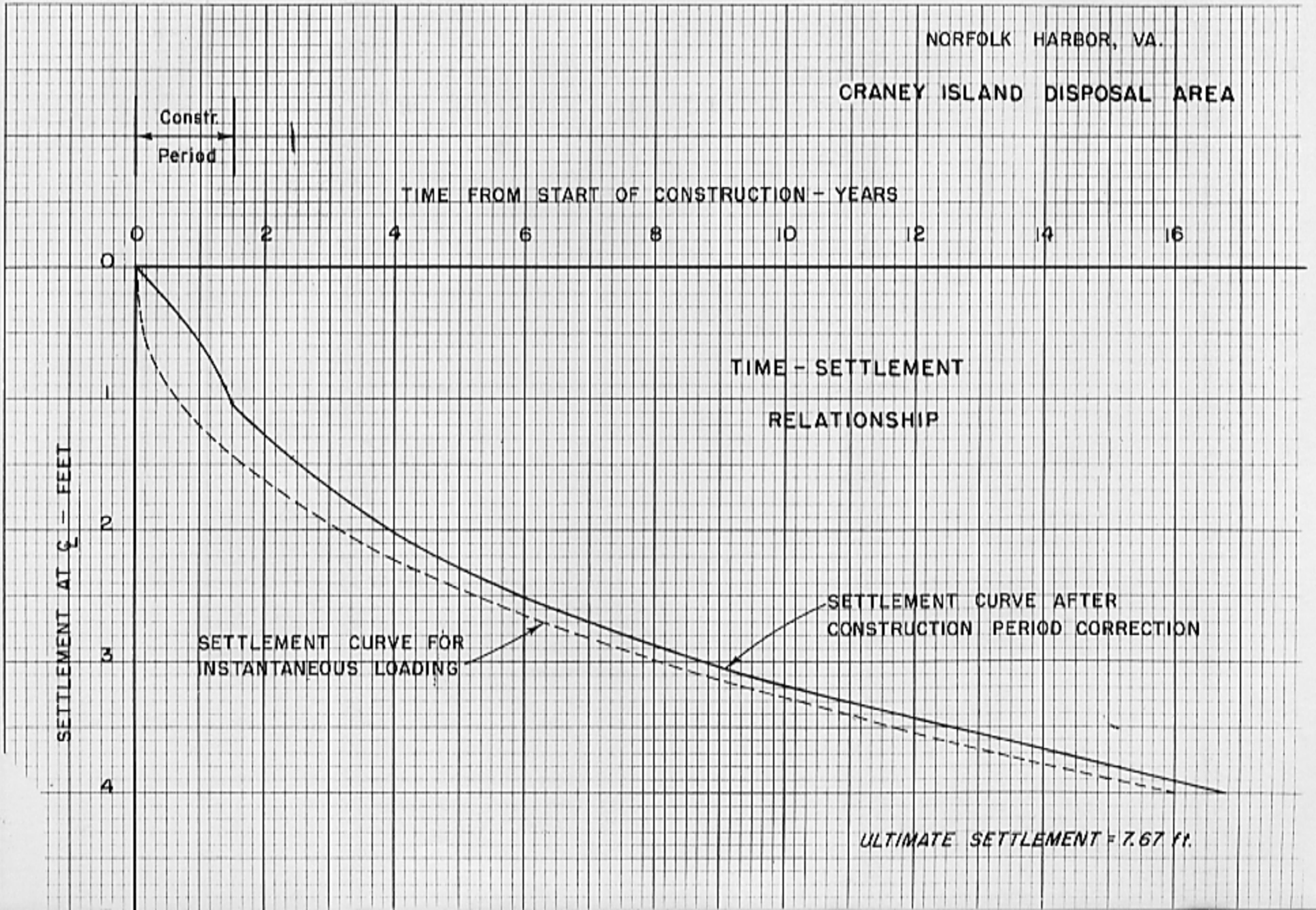

NORFOLK HARBOR, VA.
CRANEY ISLAND DISPOSAL AREA
CONSOLIDATION CURVES
ESTABLISHED
FOR
SETTLEMENT ANALYSIS
Zone Depth (ft)
A -10 to -30
B -30 to -60
C -60 to -90
D below -90
VOID RATIO - e
3.0
2.8
2.6
2.4
2.2
2.0
VERTICAL LOAD - TONS PER SQUARE FOOT
0.1
0.5
1.0
5.0
D
C
B
A

Exhibit VII



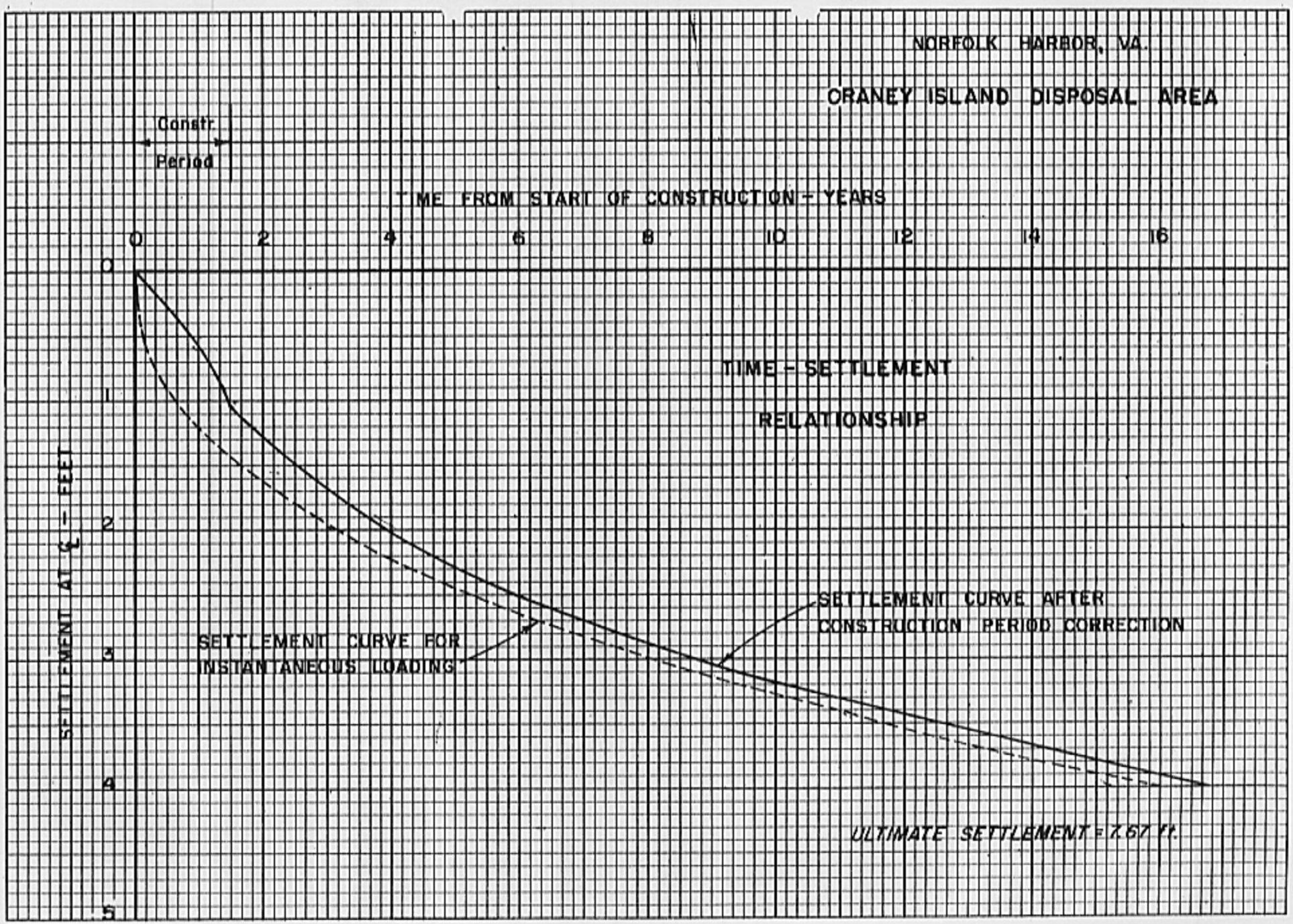


Exhibit VIII

NORFOLK HARBOR, VA.

CRANEY ISLAND DISPOSAL AREA

GENERAL DESIGN MEMORANDUM

SUBMITTED 24 MARCH 1953

REVISED 10 NOVEMBER 1953

APPENDIX II

DESIGN

CORPS OF ENGINEERS
U. S. ARMY
NORFOLK DISTRICT

CONTENTS

LIST OF TABLES

A. INTRODUCTION

1. Scope. The purpose of this appendix is (1) to indicate design investigations, including navigation, hydraulic, and structural analyses made of the various features of the improvement, and (2) to describe the proposed general construction program.

2. Surveys. Topographic maps for the adjacent shore were prepared to scale 1" =200 feet and a contour interval of two feet. Hydrographic maps were prepared to scale 1 : 2400. Maps were also prepared to scale 1 : 20,000 showing the location of sand borrow areas and sand stratification. Maps showing the location of borings and graphic logs of the borings were prepared. (Plates 3 and 4)

B. SITE

3. Description. The site of the improvement is on Craney Island Flats immediately north of Craney Island, 3,500 feet westerly of Norfolk Harbor 40-foot channel, and extending northerly approximately 10,890 feet to a water depth of 10 feet below m.l.w. The site was selected because of its central location to the dredging activities in Hampton Roads. The site is located away from established lanes of navigation and fronts undeveloped waterfront property. It is the only available site within economical distance for transporting dredged material from Norfolk Harbor and adjacent waters. (Plates 1 and 2)

4. Foundation. Results of subsurface investigations show that the stratum underlying the site is basically marine clay interspersed with thin layers of fine sand and sea shells. Depths to firm material range to over 100 feet below mean low water. Logs of the borings taken are shown on Plate 3. Detailed analyses of subsurface conditions are given in Appendix I.

C. CAPACITY

5. Annual dredging program. The estimated quantities of dredged material which could be expected to be deposited in the area were compiled from records of the District for the period 1932 - 1952.

Table II-1

Tabulation of Estimated Quantity of Dredged Material to Be Deposited in Craney Island Disposal Area.

Description	Hopper Dredge Cu. Yds.	Bucket Dredge Cu. Yds.	Total Cu. Yds.
Corps of Engineers Channel Maintenance	1,660,500	80,000	1,740,500
U.S. Navy & Other Government Agencies	901,800	300,000	1,201,800
Private Concerns		667,700	667,700
Estimated Annual Maintenance of Proposed Norfolk Harbor Widening	690,000		690,000
Total	3,252,300	1,047,700	4,300,000

The above tabulation represents gross in place quantities which may be anticipated to be deposited in the disposal area annually and include allowances for anticipated new work.

6. Required storage capacity. The disposal area was designed to provide adequate capacity to receive all material anticipated to be dredged during a 22-year period from the Hampton Roads area with the exception of York Spit Channel and Thimble Shoal Channel. Material dredged from these channels is normally transported to disposal areas in Chesapeake Bay or in the Atlantic Ocean beyond Cape Henry. It was planned that the land within the limits of the disposal area would eventually be built up to an elevation similar to land within the U.S. Naval refueling station at Craney Island which would be a maximum of about 18 feet above mean low water. The easterly limit of the disposal area was selected at a distance of approximately 3500 feet from Norfolk Harbor 40-foot channel in order to assure ready access to the rehandling basins and at the same time avoid any filling in the channel during the construction of the levee by hydraulic method. The northerly limit of the disposal area was selected at the approximate limit of Craney Island Flats or at a depth of approximately 10 feet below mean low water. This was also considered to be the maximum depth at which the retaining levees could economically be constructed. The westerly limit of the disposal area was determined from the desired capacity of the area, the average depth of water within the proposed boundaries and the height to which it was planned to make the fill. The adopted area was trapezoidal in shape, with its easterly limit parallel to and 3500 feet west of the Norfolk Harbor 40-foot channel, and extending 11,050 feet north from the northerly limit of Craney Island with widths of 9000 feet and 11,100 feet at its offshore and inshore ends, respectively. Ample area and depth would be provided in the rehandling basins to permit efficient rehandling operations. Two rehandling basins 200' x 800' would be dredged to elevation 40-feet below mean low water. The use of two rehandling basins would permit the simultaneous operations of dumping and rehandling.

7. An approach and exit area, 3800 feet long and 600 feet wide would be constructed to provide suitable access to the rehandling basins from Norfolk Harbor 40-foot channel. The area would be dredged to a depth of 31 feet below mean low water to accomodate all drafts of loaded scows and hopper dredges. (Plate 2)

D. DESIGN ASSUMPTIONS

8. The design of the several features of the project would be based on the following basic assumptions:

Weight of concrete	150 lbs. per cu. ft.
Weight of sea water	64 lbs. per cu. ft.
Weight of sand (dry)	100 lbs. per cu. ft.
Weight of sand (submerged)	60 lbs. per cu. ft.
Weight of clay (submerged)	32 lbs. per cu. ft.
Weight of riprap (dry)	100 lbs. per cu. ft.
Weight of riprap (in water)	60 lbs. per cu. ft.
Bearing power of timber piles	20 tons on sluiceways
	15 tons elsewhere

9. Construction plans and specifications for the Craney Island Disposal Area will be based on the plan presented herein, although certain refinements in the structural design will result from detailed studies made in connection with the final design.

B. DESIGN FEATURES

10. General layout. As shown on Plate 2 the definite project plan calls for (1) the construction of approximately 30,830 feet of stone faced sand fill levees bounding a trapezoidal area of approximately 2,500 acres; (2) construction of three treated pile and timber sluiceways; (3) construction of 2,500 linear feet of treated pile and timber pipeline trestle; (4) construction of two rehandling basins 200 feet by 800 feet and an access area 600 feet wide by 3,800 feet long; and (5) construction of an access road to the levee. In addition to these features, the plan contemplates the provision of rehandling plant.

11. Navigation. The site of the disposal area was selected as the most favorable to provide a fairly protected site for dumping and to eliminate the present exposure to scow tows moving from points of dredging in Norfolk Harbor to the dumping grounds now in use. The site would be equally advantageous to the hopper dredge COMBER or other government dredges of the hopper type, performing maintenance work in Norfolk Harbor. Being centrally located to all dredging operations in Norfolk Harbor and its adjacent waters, the site would effect a saving in overall dredging costs in the Hampton Roads area.

12. Hydraulic. The mean tidal range in Norfolk Harbor is 2.7 feet as recorded at the Norfolk Naval Base. However, Hampton Roads is subject to storm tides and winds and the retaining levees would be subjected to severe wave action during storm tides. The maximum tide of record is 9.6 feet above m.l.w. as recorded during the hurricane of 23 August 1933, at which time the recorded wind velocity was approximately 60 miles per hour. Assuming an open water fetch of 5 miles and a maximum velocity duration of 60 minutes, a wave crest of 7.0 feet above wave trough was calculated using the method outlined in Special Issue No. 1 (July 1, 1948) of the Beach Erosion Board and Engineering Manual, Part CXXIX, Chapter 4. However, consideration was given to the effect of transitional or shallow water and the flat slopes which would act as a spending beach and tend to cause the waves to break and expend a portion of their energy before reaching the revetment. Allowance was also made for the effect of refraction as the waves approach the levees. For these reasons, it was determined that the maximum design height could safely be reduced to 4.7 feet on the Hampton Roads side of the levee and 2.0 feet on the disposal area side. During periods of storm tides, the levees would be subjected to severe wave action. The levee revetment is therefore shown to be reinforced by a heavier and thicker revetment on the outside face because of its exposure, and the top of the levee is to be protected by crushed stone as a protection against scour from waves. The pipeline trestle and sluiceways must also be heavily braced with lateral and longitudinal bracing.

13. To meet the need for adequate drainage of adjoining Navy property when the fill in the disposal area progressed shoreward, a ditch would be constructed, as an operation and maintenance measure, in a westerly direction along the existing shore line to the westerly limit of the disposal area. Studies of topography and existing drainage conditions in the adjacent area revealed that a ditch with an 8-foot bottom width and 1-1/2 on 1 side slopes would provide adequate drainage. The material from the ditch would be deposited on the disposal area side of the ditch to form a protective levee.

14. Structural. Structural design of the sluiceways will be in accordance with standard practices. The assumed live loading would consist of one 30-ton crane which would be used during maintenance operations to repair the revetment. The sluiceways would also be constructed to withstand maximum wind and wave forces. Pile penetrations and spacing would be such as to withstand the loading without settlement of the structure.

15. The pipeline trestle would have a deck height of +8.0 feet above mean low water. The bottom elevation at this locality and the soft nature of the foundation demand that the structure have sufficient length of piles and bracing to withstand strong wind and wave action without side sway, and also sufficient capacity to carry the live load weight of the 24-inch pipeline filled with the dredge discharge material weighing approximately 70 lbs. per cubic foot.

16. Soils. Investigations were made to determine the stability of the levees and the amount of displacement of the foundation material during construction and settlement as a result of long term consolidation during the life of the project. The stability investigations as they pertain to the assumed levee section are contained in Appendix I.

17. Slope protection. Because of the shelter afforded the inside dike slopes by the opposite side of the disposal area, in contrast to the relatively exposed exterior slope, economical design practice required that slope protection be investigated separately for the two sides. The fetch associated with interior faces is assumed to be the diagonal distance within the dike boundaries. This is approximately 14,100 feet, or 2.7 miles. The maximum fetch for the outside faces is considered to be 5 miles. The maximum wind velocity is considered to be 60 miles per hour for both inside and outside faces. Results of wave height calculations are given in Table II-2. Inside wave heights have been reduced one-half and outside wave heights one-third to allow for the effect of transitional or shallow water and the flat slopes, as well as the effect of wave refraction as described in Paragraph 12.

Table II-2

Maximum Wave Heights

Reference	Wave Height in Feet			
	Inside Face		Outside Face	
	Computed	Adjusted	Computed	Adjusted
"Low Dams," published by the Water Resources Committee of the National Resources Committee (1938), p. 145	3.7	1.8	4.5	3.0
"Engineering for Dams," by Hinds-Creager-Justin, p. 274-276, Fig. 18	3.4	1.7	4.0	2.7
"Slope Protection for Earth Dams," by Waterways Experiment Station (March 1949), p. 11, Fig. 4	4.2	2.1	6.3	4.2
"Relationships Between Wind and Waves, Abbotts Lagoon, California," by J. W. Johnson, Trans., AGU, June 1950	4.1	2.0	6.5	4.3
Molitor's Formula	3.4	1.7	4.0	2.7
"Engineering Manual, Civil Works Construction," Part CXXIX, Chapter 4	4.1	2.0	7.0	4.7
Adopted heights		2.0		4.5

18. In selection of the type of slope protection best suited for the dike, consideration was given to dumped riprap, hand placed riprap, and concrete slab. Because of the settlement expected, the certainty that hydrostatic pressure would be developed beneath the slab, and difficulty and cost of construction, concrete slab slope protection was deemed unsatisfactory. While hydrostatic pressure was not a serious problem with hand-placed riprap, and the cost is probably less than concrete protection, the single-course construction and large settlement expected within the dike indicates that maintenance costs would be large, if not prohibitive. Construction would be complicated within the range of tide fluctuation. It was concluded that dumped riprap offered the best and most practical means of protecting the dike slopes.

19. Based on criteria given in (a) Part V of the Waterways Experiment Station publication, "Slope Protection for Earth Dams," dated March 1949, (b) Civil Works Engineer Bulletin 52-15, "Slope Protection," dated 2 June 1952, and (c) Plate 12 of Chapter 8, Part CXVI, Engineering Manual for Civil Works Construction (Preliminary), dated July 1952, the rock size and riprap thickness requirements, assuming a specific gravity of stone of 2.68, are as follows for the adopted wave heights:

Table II-3

Recommended Stone Sizes

Interior Slope	Rock Size
Reference (a) above	10" (min. average)
Reference (b) above	200 to 500 lbs. (maximum)
Reference (c) above	70 lbs.
Adopted	200 lbs. (nominal)
Exterior Slope	
Reference (a) above	15" (min. average)
Reference (b) above	500-1500 lbs. (maximum)
Reference (c) above	400 lbs.
Adopted	1000 lbs. (nominal)
Interior Slope	**Riprap Thickness**
Reference (a) above	15" min.
Reference (b) above	12"
Adopted	12"
Exterior Slope	
Reference (a) above	22" min.
Reference (b) above	24"
Adopted	24"

For the interior slopes the rock size finally selected is such that the stone may be placed by means of a skip-pan, and a riprap thickness adopted approximately equal to the dimensions of the average size stone. For the exterior slopes, the 1000 lb. rock size adopted corresponds to a riprap thickness of approximately 20 inches. The fine sand to be used for the dike fill will make it necessary to provide a filter blanket between the hydraulic fill and the riprap. Single-layer filters 6 and 9 inches in thickness are considered to satisfy the requirements of the interior and exterior slopes, respectively. The material should be a 2-inch crusher-run product, graded as recommended in the Waterways Experiment Station publication referenced above.

20. Comparison of the results of this analysis with the project document and the comments of the Shore Protection Board thereon as contained in Office Memorandum, Shore Protection Board to Board of Engineers for Rivers and Harbors, dated 14 May 1945, subject: "Review of Reports on Norfolk Harbor, Virginia," indicates the following differences:

Table II-4

Comparison of Adopted Slope Protection
with Previous Recommendations

	Project Document	Recommended by Shore Protection Board	Recommended in General Design Memorandum
Inside Slope			
Riprap thickness	48"	12"	12"
Stone size	Derrick-stone	One-man	200 lb.
Filter thickness	12"	6"	6"
Outside Slope			
Riprap thickness	48"	36"	24"
Stone size	Derrick-stone	Quarry-run (1)	1000 lbs.
Filter thickness	12"	12"	9"

(1) It was recommended by the Shore Protection Board that, if handling of quarry-run stone by shovel is not feasible, a 2-foot layer of derrick-stone should be used instead, plus a 1-foot layer of one-man stone between the derrick-stone and the filter bed, thus forming a two-layer riprap blanket.

21. Access road. An access road 3500 feet in length would be provided for use by the contractor during construction operations and to provide access for future maintenance without entering Navy property. The alignment would follow the west property line of the U. S. Naval Refueling Station from a junction with Virginia State Highway 655 to the shore line of Hampton Roads and turn westerly to the west levee in order to eliminate severance of adjacent lands. The design wheel load capacity would be 9,000 lbs. Horizontal curvature would be reduced to a minimum consistent with economical design. The profile would vary from elevation +8.0 feet to +18.0 feet, and grades would be limited to a maximum of 1-1/2 per cent. The road bed would be constructed with a top width of 26 feet with 1 on 1-1/2 slopes in fills and 1 on 1 slopes in cuts. Drainage of adjacent property would be provided by a 24" reinforced concrete pipe culvert. The surfacing would be 18 feet wide and consist of 6 inches of crushed stone with a suitable binder. Compaction methods would conform with Standard Method T-99 of the American Association of Highway Officials.

F. CONSTRUCTION FEATURES

22. Required material. The following approximate quantities of materials will be required for construction of the project:

Table II-5

Construction Quantities

Item	Quantity
Crushed stone surfacing	82,400 sq. yds.
Sand fill	7,670,000 cu. yds.
Riprap stone (nominal 1000 lb.)	87,200 tons
Riprap stone (nominal 200 lb.)	40,000 tons
Crushed rock	58,900 tons
Treated timber piling	59,180 lin. ft.
Treated structural timbers	143.43 MBM
Galvanized iron hardware	21,440 lbs.
Rehandling plant	lot

23. Access. Access to the site could be had from available roads and railway connections as shown on Plate 2. Permission for use of and connection to the facilities would be acquired from responsible Naval and railroad authorities before commencement of construction operations. Use of roadways within the limits of the U. S. Naval Refueling Station would be necessary in order to have direct access to the levees.

24. Levees. The retaining levees would be constructed to elevation +5.0 feet above mean low water by hydraulic method. Extensive borings were taken to develop suitable borrow areas adjacent to the shore line and the junction with the west levee (Plates 2 and 4). Sufficient material is available immediately below the surface of the borrow areas to provide for construction of the levees without the necessity of first removing over-burden. (Plate 4)

25. The construction of the levees would proceed from the shore outward with the dredge pipelines laid along the top of the levee as work progressed. Bleeder pipes would be used above the water line to construct the planned slopes and eliminate wash from the discharge line. It would also be necessary to break back the discharge line as many times as required to stabilize the levee fill and bring the center up to elevation +5.0 feet m.l.w. Sufficient additional material would be pumped near the center line of the levee to provide borrow for construction of the remainder of the fill between elevation +5.0 feet and +8.0 feet by land equipment.

26. The site of the work is exposed to storm tides and wind and wave action which would delay the levee construction at times and would also damage the sand fill if not thoroughly protected. For this reason it would be necessary to follow the hydraulic sand filling operation

closely with the stone revetment. The additional sand fill to complete the levee to elevation +8.0 would be obtained from side borrow and excavation of the toe trench for the stone. The trench would have to be excavated during the period of low tide and the stone placed on the banks as the tide rose in order to eliminate damage to the prepared slopes by the lapping of the tide and waves.

27. Material for the revetment would be loaded directly into railroad cars at the commercial quarry and transported to the construction site by rail. Facilities would be provided for storage and unloading of the cars directly into trucks which would transport the stone to the point of placement. Large cranes equipped with specially constructed skip pans for dumping the stone would be utilized to place the stone upon the slopes. Hand labor would be required to smooth the stone to workmanlike job and to chink all holes in the revetment with spalls. The project is situated in a region wherein there are no stone quarries. The source of riprap stone is therefore limited to shipment of stone from quarries that are over 100 miles distant. Several quarries are available where suitable stone can be obtained by competitive bidding. The Bryan Rock and Sand Company, Inc. of Raleigh, N. C., has indicated that stone could be furnished.

28. Sluiceways. Construction of the sluiceways would be initiated after pumping of the retaining levees. Land equipment would be utilized for the construction operation. The waterway through the retaining levee would be excavated to elevation +2.0 feet m.l.w. by clamshell or dragline bucket.

29. Pipeline Trestle. The pipeline trestle would be constructed by floating equipment. It would be constructed at any time prior to completion of the disposal area and start of rehandling operations.

30. Rehandling Basins. Dredging of the rehandling basins would be contingent upon completion of the disposal area. The material would be removed by hydraulic methods and would be pumped directly into the disposal area.

31. Navigation Aids. Construction of the navigation aids would be done in connection with the pipeline trestle and would be completed before rehandling operations could be commenced.

32. Construction schedule. The estimated time of construction is 2-1/2 years. Construction funds have been made available in fiscal year 1954 and a contract will be awarded 1 April 1954. The work would be accomplished under a continuing contract. The first stage of construction from 1 April 1954 to 30 June 1954 would consist of constructing the levees from station 0+00 to station 30+00, purchase of lands, and leased oyster beds, and construction of access road. The second stage of construction from 30 June 1954 to 30 June 1955 would consist of construction of the retaining levees from station 30+00 to 185+00, and initiation of construction of the rehandling plant. The third stage of construction from 30 June 1955 to 30 June 1956 would consist of construction of the retaining levees from station 185+00 to station 308+00, construction of the rehandling basins, range range markers, pipeline trestle, sluiceways, navigation aids, and completion of construction of the rehandling plant.

NORFOLK HARBOR, VA.

CRANEY ISLAND DISPOSAL AREA

GENERAL DESIGN MEMORANDUM

SUBMITTED 24 March 1953

REVISED 10 November 1953

APPENDIX III

REHANDLING PLANT

NOTE: Design memorandum on Rehandling Plant will be submitted as supplement to this report.

CORPS OF ENGINEERS
U. S. ARMY
NORFOLK DISTRICT

NORFOLK HARBOR, VA.

CRANEY ISLAND DISPOSAL AREA

GENERAL DESIGN MEMORANDUM

SUBMITTED 24 MARCH 1958

APPENDIX IV

LANDS

CORPS OF ENGINEERS
U. S. ARMY
NORFOLK DISTRICT

CONTENTS

LIST OF TABLES

A. INTRODUCTION

1. Authorization and Scope. The following report is prepared in accordance with paragraph 5201.05a, Orders and Regulations. It covers an outline of the Real Estate problems involved and gives an estimate of the costs of all land interests necessary for the project.

2. Location of the Project. The project is located in Western Branch Magisterial District, Norfolk County, Virginia, adjacent to and North of the U. S. Naval Installation at Craney Island. It is approximately 5 miles across Hampton Roads from Norfolk, Virginia, and approximately 10 miles southeast of Newport News, Virginia.

B. GENERAL DATA

3. Real Estate Involved. The real estate involved consists of 3,400 acres of submerged land in the Craney Island Flats area, 38.2 acres of privately owned land adjoining on the South, 18.7 acres of oyster bottom within the area, 87.8 acres of oyster bottom outside the area and a permit from the Navy Department to allow the construction of the protective levee and drainage ditches adjoining its property, and the use of roads within the Craney Island installation. These properties are indicated on Plate 2 of this report.

4. Submerged Land. The 3,400 acres of submerged land was deeded to the Government by the State of Virginia on 19 June 1948, which deed was recorded in the Circuit Court of Norfolk County, Virginia, 2 December 1948, Book 932, Page 283, to satisfy the required conditions of local cooperation that it would:

a. Convey to the United States, by appropriate legislation or otherwise, title to the submerged lands permanently occupied by the disposal area and terminate all existing oyster leases in effect within the limits of the disposal area; it being understood that the United States will compensate private oyster growers for crops in production on the submerged lands at the time of occupancy by the United States.

b. Terminate prior to the initiation of the construction and for the useful life of the disposal area, the leases of private oyster growers for leaseholds in areas on the south side of Hampton Roads which may be necessary for the construction, maintenance, and operation of the disposal area, including dredging for fill material adjacent to the disposal area; it being understood that at the time of the termination the United States will compensate these oyster growers for crops in production.

c. Except as provided in (a) and (b) above, release the United States from all claims for such damages as may occur to public or leased oyster bottoms from the construction, maintenance, and operation of the project.

5. Land to be Acquired. On the south the Disposal Area borders on high land, the larger part of which is property of the U. S. Navy. On the western part of the south boundary the area borders on a privately owned 198.9 acre tract, which is used at present as a home and farm, and is improved with a very substantial home and appropriate outbuildings. Due to the exceptionally fine view of the Norfolk

Harbor, this tract has a high value as a possible subdivision, and only the fact that the water is very shallow with a long distance to the harbor channel prevents this tract from having a very high commercial value. Rail facilities are available on the adjoining property of the Navy.

6. Present plans call for the fee acquisition of 38.2 acres of the above mentioned 198.9 acre tract, consisting of 8.1 acres of high land to be used as an access road and for a buffer strip, approximately 11.7 acres of land lying between the high and low water marks, and 18.4 acres of land formerly used as a borrow pit.

7. There is a strong probability that a connecting route between Norfolk and the vicinity of Newport News will be constructed within several years. The route as presently recommended does not effect subject property; however, an alternate route is being urged by certain interests, which route would cross the 198.9 acre tract. Should this alternate route be adopted, property in this taking would increase in value to several times it's present worth.

8. A permit will be obtained from the Navy Department to permit use of its roads at the Craney Island installation, and the construction of a drainage ditch and protective levee adjoining its property.

9. Riparian Rights. The deposit of dredged material in this area over a period of years will be unsightly, will eventually become fast land, and will completely destroy the riparian rights of the land opposite the project. It is the opinion of the Legal Branch of the Norfolk District that any damages sustained by the riparian owner in this case are not recoverable, therefore, no value has been assigned to cover these damages.

10. Oyster Bottoms. Nearly all of the submerged area donated by the State of Virginia is a part of State owned public oyster grounds, 18.7 acres of which are privately leased. In addition, it is estimated that approximately 1,560 acres of public oyster grounds, or bottom, and 87.8 acres of privately leased bottom will be destroyed or damaged as a result of the sluicing of sediment through the west levee, or for use as a sand borrow area.

11. All damages to public oyster beds resulting from the construction, operation and maintenance of the project were released by the State of Virginia in House Bill No. 381, approved 2 April 1948. The Government will, however, be required to compensate all oyster growers who hold leases for crops in production in areas necessary for the project. Names of growers and acreages leased by them are as follows:

TABLE IV-1

Leased Oyster Bottom

Grower	Acreage
J. H. Miles & Company	18.7
J. H. Miles & Company, R. L. Miles	87.8

12. Oysters on the 18.7 acres bottom (designated as areas A & B on plate 2) were damaged as a result of the construction of the Craney Island Navy Installation, and a suit was entered by J. H. Miles & Company, the lessee, against the contractor responsible. In a recent decision by the United States District Court, it was decided that this oyster bottom was a part of the public oyster ground, was illegally leased, and that Miles & Company were not entitled to damages. This decision is now being appealed. In view of said decision, and the fact that the grounds were almost totally damaged, no value has been assigned for this particular tract of oyster ground.

13. The 87.8 acres of leased bottom (designated as areas C & D on plate 2) are used by a large oyster packing company as a deposit for oysters transferred from polluted grounds. These oysters are left for a sufficient time to become fit for consumption, or until needed, and are then taken to the packing plant for market. According to the lessee, at times he stores 800 or more bushels of oysters per acre on the grounds, which at the present market have a value of $3.00 per bushel, or $2,400 per acre.

14. If sufficient notice is given the lessees, they will be able to remove nearly all of their crop. In the spring, approximately 6 months notice would be necessary, since oysters are not harvested during the summer months. Since it is intended to allow a reasonable time for removal of the oysters, the amount of estimated damages is believed to be sufficient to cover such oysters as they remain.

(1) It is proposed, upon approval of the General Design Memorandum to notify the lessees immediately, and to request that all oysters be removed, allowing as much time as possible. The Lessee has informally agreed to remove the oysters upon receipt of this notice. At the same time the State will be requested to cancel the leases at the end of this period. Upon removal an appraisal will be made to determine the amount due the holder of the lease.

(2) In view of the fact that leases executed by the State of Virginia to private oyster growers are for a term of twenty years each and have no cancellation provisions, and also the fact that there is no statutory authority in Virginia for the State to revoke or cancel these leases, the State of Virginia would have to exercise its power of eminent domain to effect an involuntary termination of the leases of private oyster growers for leaseholds in the disposal area or on the south side of Hampton Roads. Prior to initiation of work, it is proposed that the Federal Government and State jointly negotiate with the lessees for voluntary termination of these leases; the Government's obligation being limited to the actual cost of the oyster crop in production with the State being obligated to pay for all damages, if any, attributable to the unexpired term of the leases.

(3) In the event voluntary termination negotiations are not successful, condemnation proceedings will be initiated with both State and Federal Government participating as their interests may appear.

15. Minerals, Relocations and Public Utilities. There will be no relocations necessary as a result of land acquisition.

16. There are no minerals, and no public utilities are involved.

C. COMPARABLE SALES DATA & TAX LOSSES

17. Comparable Sales or Properties Offered for Sale. There have been no sales of nearby comparable properties, however, a large oil company has recently obtained options on five tracts of land located from one to two miles distant from the project for a proposed $50,000,000 oil refinery. Properties optioned are located nearer deep water than subject 198.9 acre tract but do not have as good waterfront view. Lists of properties optioned are as follows:

TABLE IV-2

COMPARATIVE REAL ESTATE SALES

Name	Acres	Amount	Amount per Acre
Kirn	243.	$200,000	$ 825
Ripley	226.7	168,350	745
Kingman Shores Corp.	140.	89,000	600
Felton	144.	136,400	950
Dennis	15.8	12,430	850

18. Assessed Value and Estimated Tax Loss. The 198.9 acre tract is assessed as follows:

Land $11,775 Buildings $16,300 Total Assessment $28,075

The tax rate in Norfolk County, Virginia, is $20 per $1,000 assessed value.

It is estimated that the tax loss to Norfolk County as a result of the taking will be $150.

D. RECOMMENDATION AS TO ESTATE TO BE ACQUIRED

19. It is recommended that the 38.2 acre tract be acquired in fee simple, and that the lessees of the 87.8 acres of oyster bottom be reimbursed for such oysters as may remain at time of occupancy by the Government. Leases of the bottom will be terminated by the State of Virginia as agreed in accordance with paragraph 14, page 6.

E. ESTIMATED COST OF LANDS AND OYSTER BOTTOM

20. The following tabulation gives a breakdown of the total estimated cost of lands:

TABLE IV-3

GROSS APPRAISAL AND ESTIMATED COST OF
LANDS AND OYSTER BOTTOM

Land Type	Acres	Unit Value	Total Value
High Waterfront	8.1	$1,250 Acre	$10,125
Land between MHW & MLW	11.7	200 Acre	2,340
Borrow Area	18.4	300 Acre	5,520
Severance			10,000
Leased Oyster Grounds	87.8	500 Acre	43,900
Total (Rounded)			$ 72,000
Contingencies 20%			14,400
Administration 15%			10,800
District Overhead (8% of administration cost)			864
Total Estimated Cost of Lands (Rounded)			$ 98,000

NORFOLK HARBOR, VA.

CRANEY ISLAND DISPOSAL AREA

GENERAL DESIGN MEMORANDUM

SUBMITTED 24 MARCH 1953

REVISED 10 NOVEMBER 1953

APPENDIX V

PROJECT COST ESTIMATES

CORPS OF ENGINEERS
U. S. ARMY
NORFOLK DISTRICT

LIST OF TABLES

TABLE V-1

SUMMARY OF ESTIMATED COST OF CRANEY ISLAND DISPOSAL AREA

Description	Amount
Retaining levees	$ 4,837,900
Sluiceways	88,500
Rehandling basins and access area	155,800
Pipeline trestle	193,700
Range markers	26,000
Lands and oyster bottom	98,000
Rehandling plant (Preliminary, subject to revision with submission of supplemental report in Appendix III)	2,394,500
Access road	28,400
Navigation aids (U. S. Coast Guard)	11,000
Preparation of Dosign Momorandum and plans and specifications	178,200
Total estimated Federal cost of Craney Island Disposal Area	$8,012,000

NOTE: The costs for material, plant, and labor assumed in the estimates reflect prevailing contract prices as of December 1952 (Engineering News-Record Cost Index 587.49) where competitive bidding by reliable contracting firms was assured. Allowances for contingencies and administrative and overhead expense are included.

TABLE V-2

ESTIMATED COST OF RETAINING LEVEES

Description	Unit	Quantity	Unit Price	Amount	
Pumping 30,830 linear feet of sand levee	Cu. Yd	7,670,000	$0.27	$2,070,900	
Embankment (borrow)	Cu. Yd	123,000	0.80	98,400	
Nominal 1,000-lb. stone	Ton	87,200	8.00	697,600	
Nominal 200-lb. stone	Ton	40,000	8.25	330,000	
Crushed stone	Ton	58,900	8.50	500,650	
Crushed stone surfacing	Sq. Yd	75,400	3.75	207,350	
Total estimated contract cost					$3,904,900
Contingencies 15%					585,730
Construction management and supervision					162,100
District overhead 4%					185,220
Total estimated cost of retaining levees					$4,837,950
Rounded Total					$4,837,900

TABLE V-3

ESTIMATED COST OF THREE SLUICEWAYS

Description	Unit	Quantity	Unit Price	Amount	
Piling (creosoted)	L.F.	12,000	$ 2.90	$34,800	
Structural timbers (creosoted	MBM	85.0	410.00	34,850	
Hardware (galvanized)	Lbs.	5,000	0.30	1,500	
Excavation	Cu. Yd	1,500	0.75	1,120	
Total extimated contract cost					$ 72,270
Contingencies 15%					10,840
Construction management and supervision					2,000
District overhead 4%					3,400
Total estimated cost of 3 sluiceways					$ 88,510
Rounded Total					$ 88,500

TABLE V-4

ESTIMATED COST OF TWO REHANDLING BASINS AND ACCESS AREA

Description	Unit	Quantity	Unit Price	Amount
Dredging	Cu.Yd.	790,000	$0.167	$ 126,400
Contingencies 15%				18,960
Construction management and supervision				4,500
District overhead 4%				5,990
Total estimated cost of 2 rehandling basins and access area				$ 155,850
Rounded Total				$ 155,800

TABLE V-7

ESTIMATED COST OF LANDS AND OYSTER BOTTOM

Description	Unit	Quantity	Unit Price	Amount	
High waterfront	Acre	8.1	$1,250	$10,125	
Lands between MHW and MLW	Acre	11.7	200	2,340	
Borrow area	Acre	18.4	300	5,520	
Severance				10,000	
Leased oyster grounds	Acre	87.8	500	43,900	
Total (rounded)					72,000
Contingencies 20%					14,400
Administration 15%					10,800
District overhead (8% of administration cost)					860
Total estimated cost of lands					$98,060
Rounded Total					$98,000

TABLE V-8

ESTIMATED COST OF REHANDLING PLANT
(Subject to revision with submission of supplemental report)
(See Appendix III)

Description	Unit	Quantity	Unit Price	Amount	
			$	$	$
Diesel electric rehandling dredge, 3600 H.P.	L.S.	1		1,400,000	
Electric booster plant, 3400 H.P.	L.S.	1		135,000	
Housing for relay station	L.S.	1		24,800	
24-inch floating pipe-line with ball joints	L.F.	1,500	105.00	157,500	
24-inch spiral welded steel shore pipe	L.F.	15,000	7.50	112,500	
Steel oil barge, 80 by 26 feet, 5-foot draft	L.S.	1		40,000	
Steel water barge, 80 by 26 feet, 5-foot draft	L.S.	1		40,000	
Electric power facilities				51,400	
Wood derrick barge, 70 by 20 feet, 6-foot draft	L.S.	1		18,000	
Diesel motor launch, 100 horse power, 10 by 40 feet, 4-foot draft	L.S.	1		50,000	
Total					2,029,200
Contingencies 15%					304,400
Construction management and supervision					60,000
Philadelphia District overhead 1-1/2%					900
Total estimated cost of rehandling plant					2,394,500
Rounded Total					2,394,500

TABLE V-9

ESTIMATED COST OF ACCESS ROAD

Description	Unit	Quantity	Unit Price	Amount	
			$		
Clearing & grubbing	Acre	1.5	320.00	$ 480	
Excavation, common	Cu. Yd	3,000	.75	2,250	
Reinforced concrete pipe	L.F.	36	8.00	290	
Concrete headwalls	Cu. Yd	3	70.00	210	
Crushed stone surfacing	Sq. Yd	7,000	2.75	19,250	
Total estimated contract cost					$ 22,480
Contingencies 15%					3,370
Construction management and supervision					1,500
District overhead 4%					1,090
Total estimated cost of access road					$ 28,440
Rounded Total					$ 28,400

TABLE V-10

ESTIMATED COST OF ANNUAL MAINTENANCE OF DISPOSAL AREA

Description	Original Cost	Annual Maint. %	Cost of Annual Maintenance	
	$		$	
Retaining levees (riprap)			100,000 (1)	
Sluiceways	105,780	5	5,290	
Access area to rehandling basins and adjacent channels			66,000 (2)	
Pipeline trestle	159,320	5	7,970	
Range markers	20,520	5	1,030	
Total				$180,290
Contingencies 15%				27,040
Inspection and supervision				3,650
District overhead 8%				16,880
Total estimated cost of annual maintenance of disposal area				227,860
Rounded Total				$227,900

NOTE: Percentages are based on estimated life.

(1) 10,000 tons of riprap at $10.00 = $100,000
(2) 300,000 cu. yds. at $0.22 = $66,000

TABLE V-11

ESTIMATED COST OF ANNUAL MAINTENANCE OF REHANDLING PLANT
(Subject to revision with submission of supplemental report.)
(See Appendix III)

Description	Original Cost	Annual Maint. % (1)	Cost of Annual Maintenance	
	$		$	
Diesel electric rehandling dredge	1,400,000	9	126,000	
Electric booster plant	135,000	9	12,150	
Housing for booster plant	24,800	5	1,240	
24-inch steel floating pipeline	157,500	15	23,620	
24-inch steel shore pipe	112,500	30	33,750	
Steel oil barge	40,000	6	2,400	
Steel water barge	40,000	6	2,400	
Wood derrick barge	18,000	8	1,440	
Electric power facilities	51,400	5	2,570	
Diesel motor launch	50,000	9	4,500	
Total				$210,070
Contingencies 15%				31,510
Inspection and supervision				3,000
Total estimated cost of annual maintenance of rehandling plant				$244,580
Rounded Total				$244,600

(1) From the schedule of overhaul and major repairs for floating plant as published by the Associated General Contractors of America, Inc.

TABLE V-12

ESTIMATED COST OF ANNUAL OPERATION OF PROJECT
(Subject to revision with submission of supplemental report. See Appendix III)

Description	Estimated Annual Cost	
Labor	$ 327,000	
Fuel	95,200	
Lubricants	1,000	
Electric Power for booster	79,800	
Total		$ 503,000
Contingencies 15%		75,450
Engineering		5,000
Surveys, inspection and supervision		15,000
District overhead 8%		47,880
Total estimated cost of operation of project		$ 646,330
Rounded Total		$ 646,300

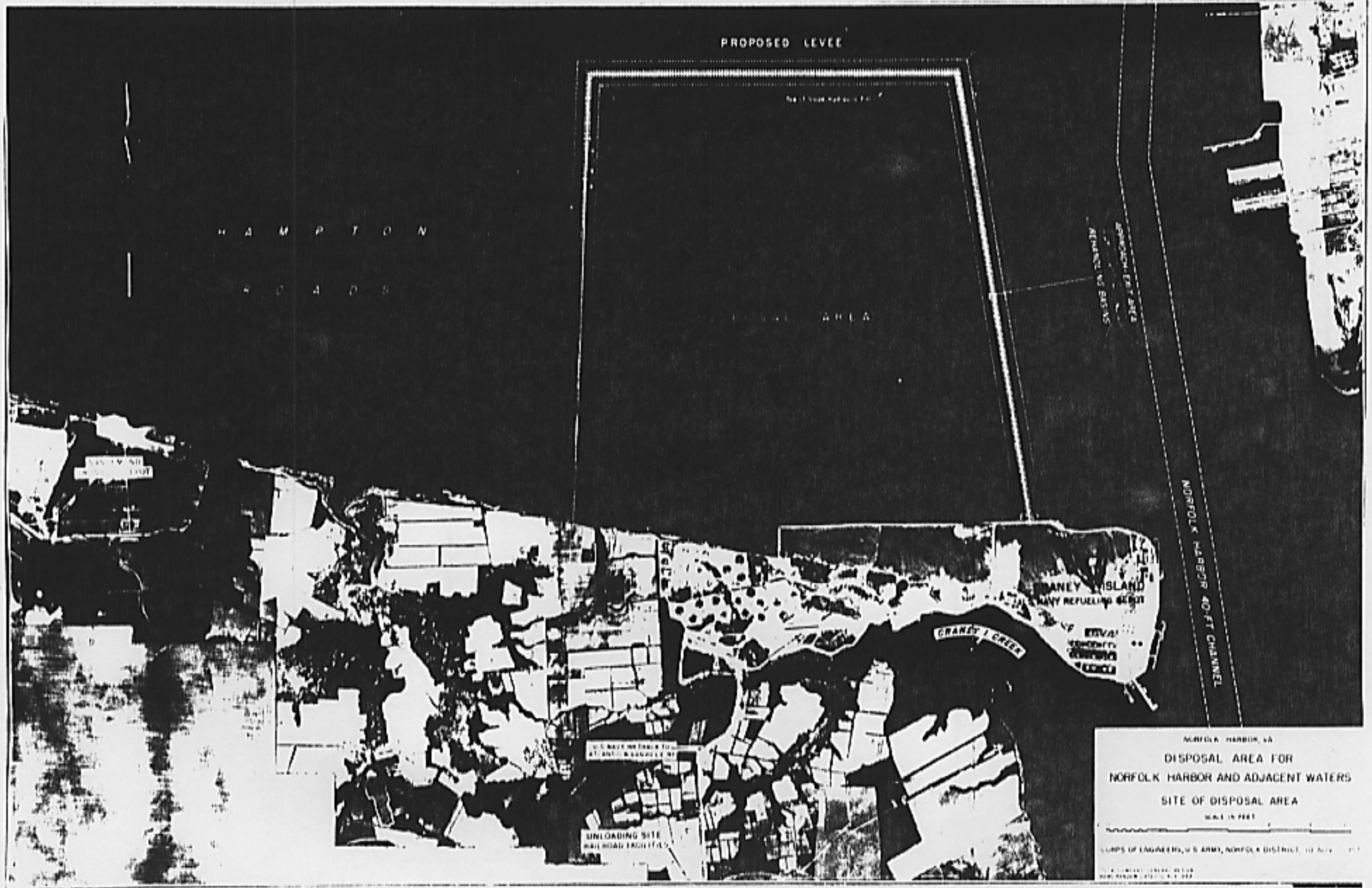
TABLE V-13

PLANT RENTAL COMPUTATION
(Based on an estimated life of 22 years)

Estimated original cost	$	2,394,500
Estimated salvage value (20% of $2,394,500)		478,900
Balance to be depreciated	$	1,915,600
Estimated annual charges:		
Depreciation	$	87,100
Repairs and replacements (Table V-11)		244,600
Cessation of work		-0-
Small tools, etc.		2,900
Total		334,600
District overhead 8%		26,770
Total annual rental	$	361,370
Rounded Total	$	361,400

CORPS OF ENGINEERS

U S ARMY



NORFOLK HARBOR, VA

DISPOSAL AREA FOR
NORFOLK HARBOR AND ADJACENT WATERS

SITE OF DISPOSAL AREA

SCALE IN FEET

CORPS OF ENGINEERS, U S ARMY, NORFOLK DISTRICT

PLATE 1

CORPS OF ENGINEERS

U S ARMY

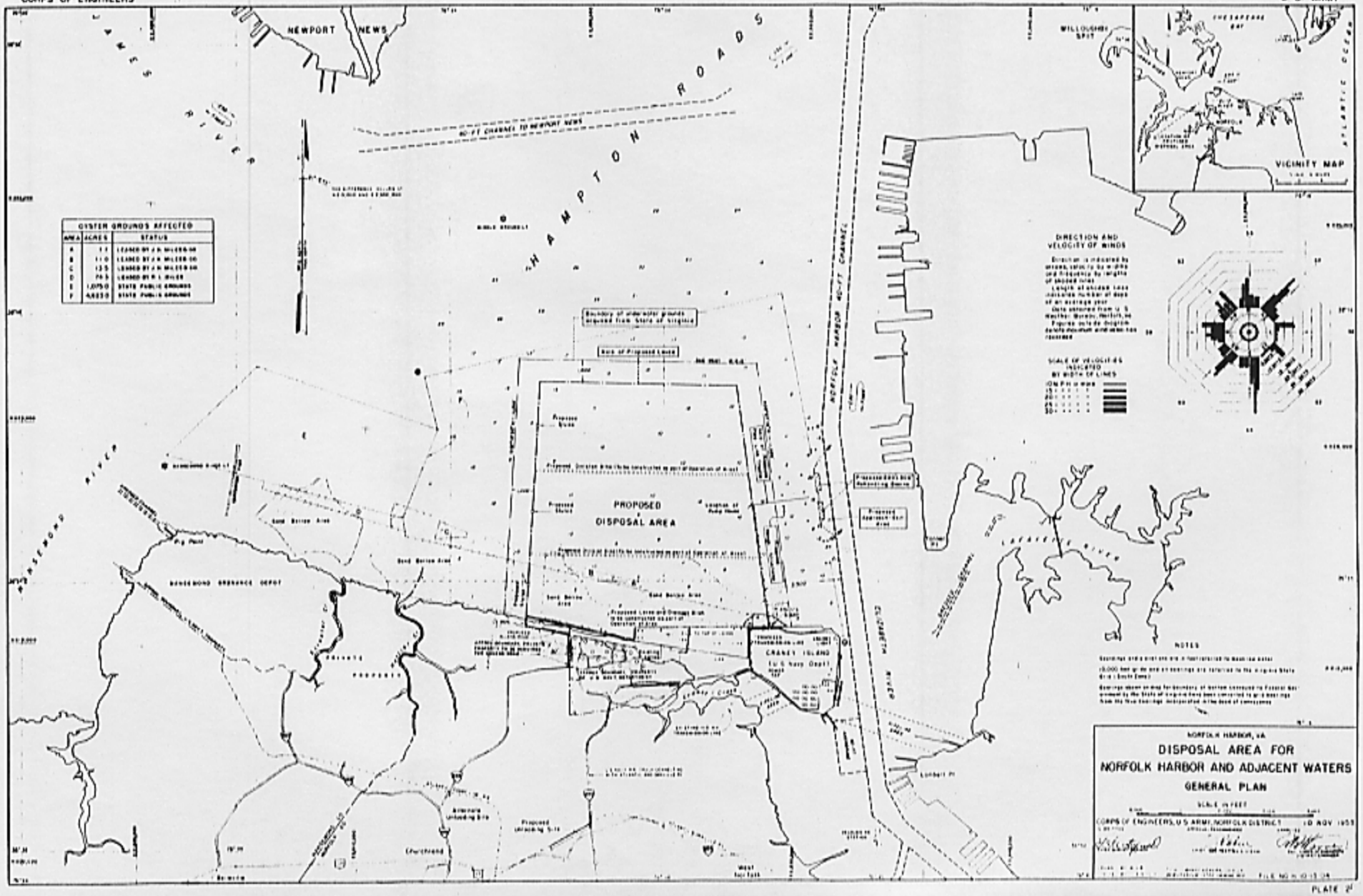
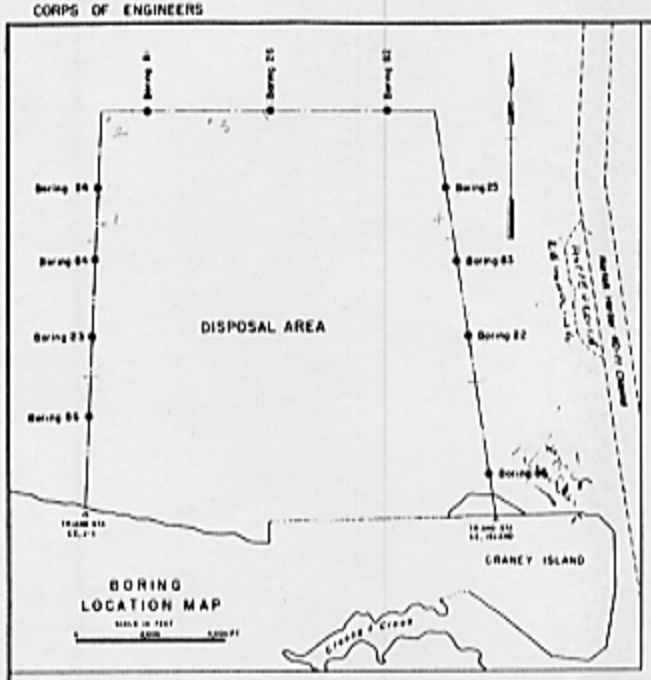


PLATE 2

CORPS OF ENGINEERS

U S ARMY



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BORING NO 23

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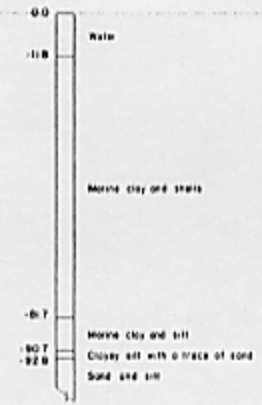

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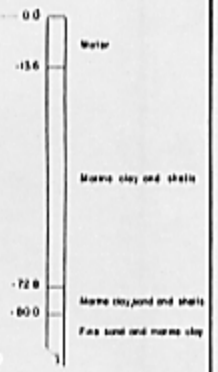

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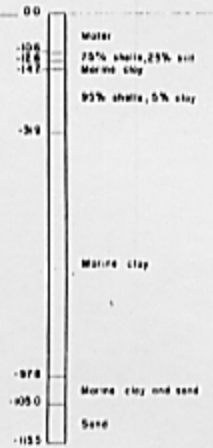
BORING NO 82



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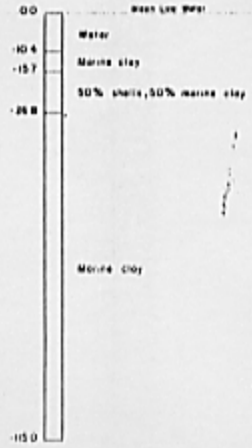

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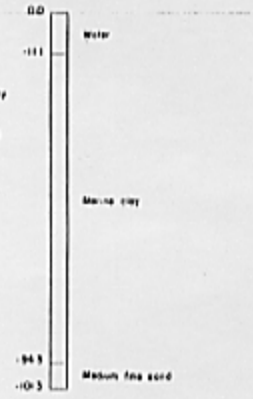

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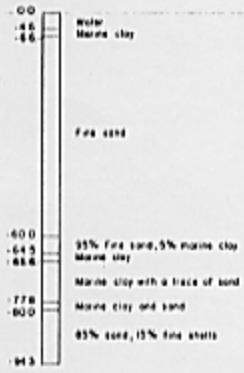

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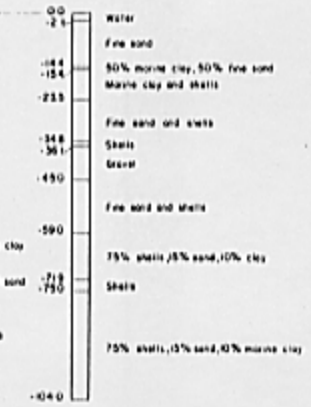


UNDISTURBED SAMPLE BORINGS

NORFOLK HARBOR, VA

DISPOSAL AREA FOR
NORFOLK HARBOR AND ADJACENT WATERS

SUBSURFACE INVESTIGATIONS
LEVEE FOUNDATION

IN 2 SHEETS SHEET NO 1

CORPS OF ENGINEERS, U S ARMY, NORFOLK DISTRICT, 10 MAY 1955

SUBMITTED APPROVED

FILE NO 11-015-04

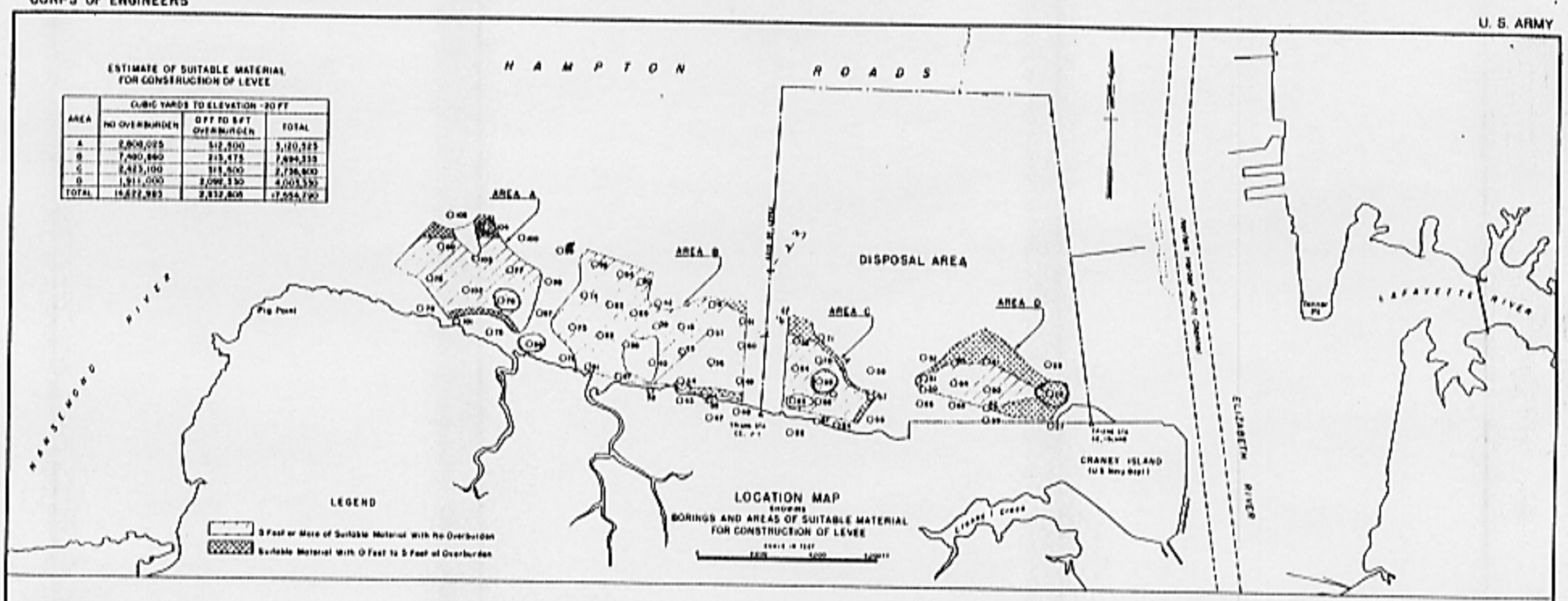
PLATE 1

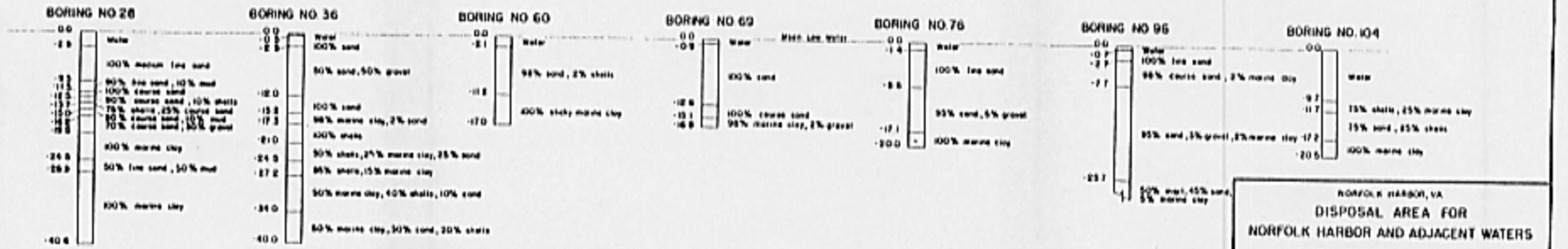
CORPS OF ENGINEERS

U. S. ARMY

ESTIMATE OF SUITABLE MATERIAL FOR CONSERVATION OF LEVEE

AREA	CUBIC YARDS TO ELEVATION -20 FT		
	NO OVERBURDEN	OFF TO 5FT OVERBURDEN	TOTAL
A	2,808,025	312,500	3,120,525
B	7,480,860	213,475	7,694,335
C	2,423,100	313,500	2,736,600
D	1,911,000	2,092,550	4,003,550
TOTAL	14,622,985	2,932,025	17,554,790





TYPICAL SAND EXPLORATIONS

NORFOLK HARBOR, VA

DISPOSAL AREA FOR NORFOLK HARBOR AND ADJACENT WATERS

SUBSURFACE INVESTIGATIONS

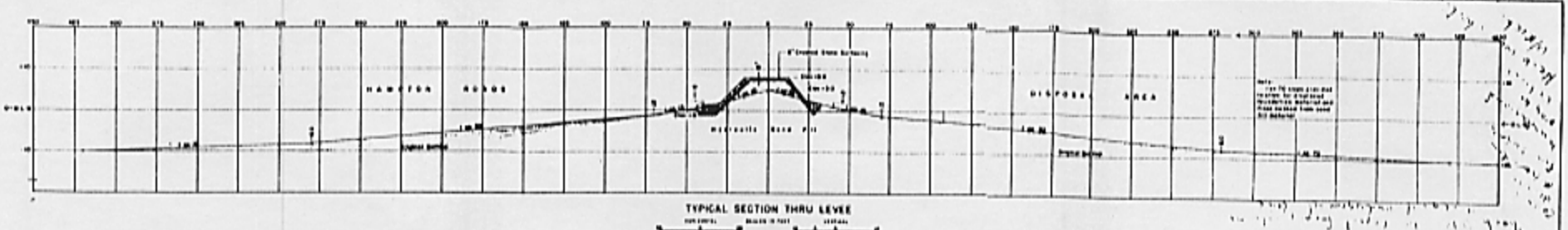
SAND BORROW EXPLORATIONS

CORPS OF ENGINEERS, U.S. ARMY, NORFOLK DISTRICT, 10 NOV 1953

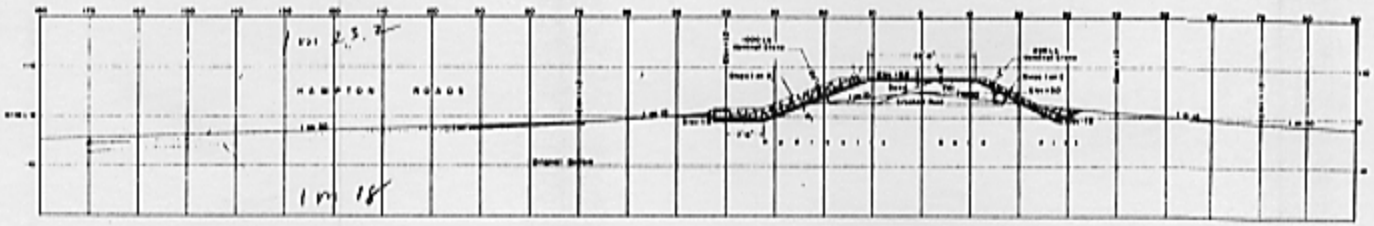
PLATE 41

CORPS OF ENGINEERS

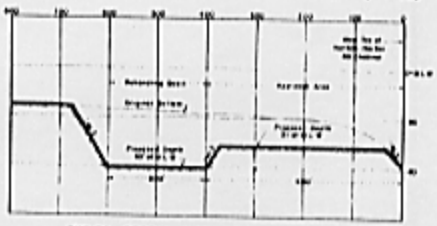
U S ARMY



TYPICAL SECTION THRU LEVEE



TYPICAL SECTION THRU LEVEE



TYPICAL SECTION THRU REHANDLING BASIN AND APPROACH AREA

PROFILE ALONG CENTER LINE OF RETAINING LEVEE

NORFOLK HARBOR, VA

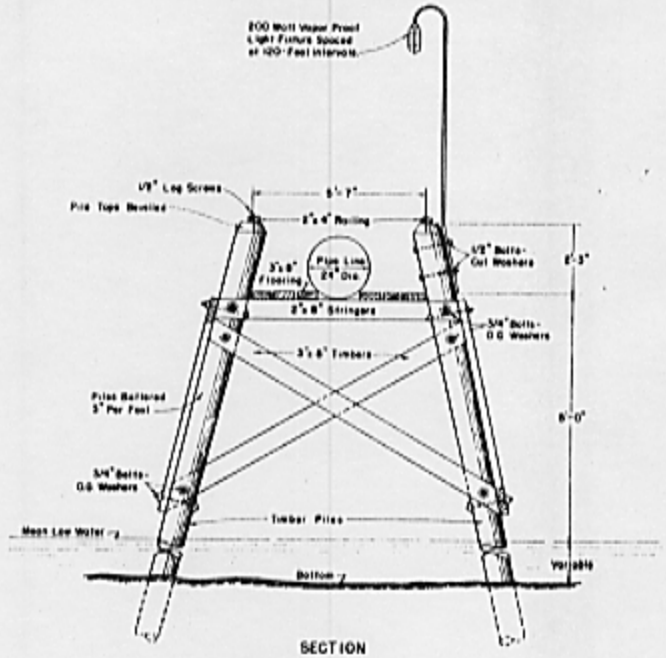
DISPOSAL AREA FOR NORFOLK HARBOR AND ADJACENT WATERS

LEVEE, REHANDLING BASIN AND APPROACH AREA

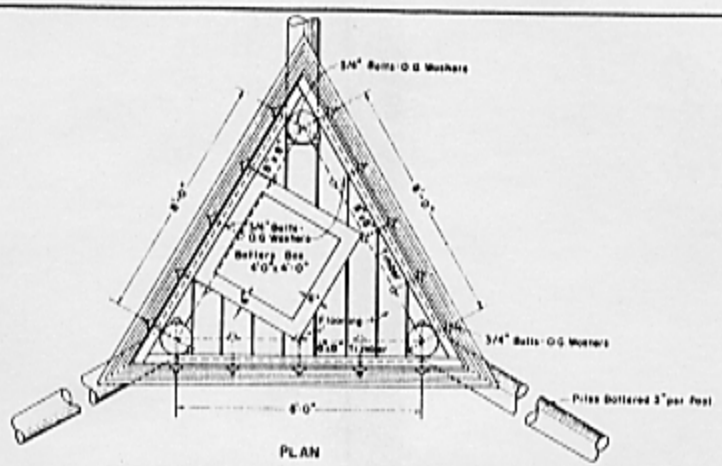
PLATE 5

CORPS OF ENGINEERS

U. S. ARMY

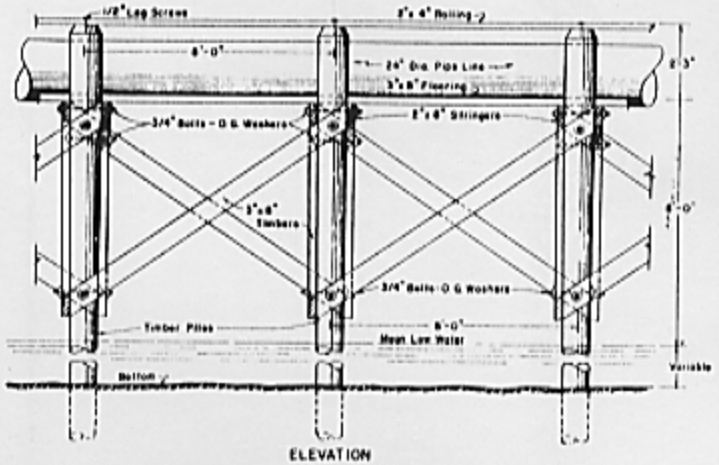


SECTION



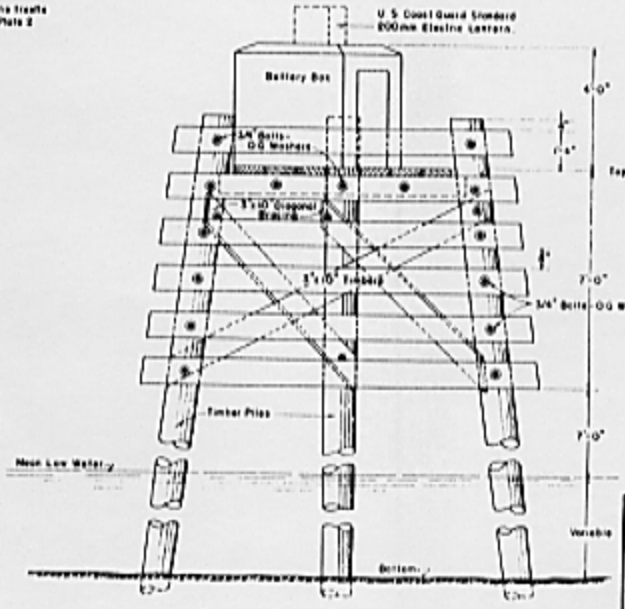
PLAN

NOTE - For location of pipe line trestle and range structures see Plate 2



ELEVATION

DETAIL OF PIPE LINE TRESTLE



ELEVATION

DETAIL OF RANGE STRUCTURE

NORFOLK HARBOR, VA

DISPOSAL AREA FOR NORFOLK HARBOR AND ADJACENT WATERS

PIPE LINE TRESTLE AND RANGE STRUCTURE

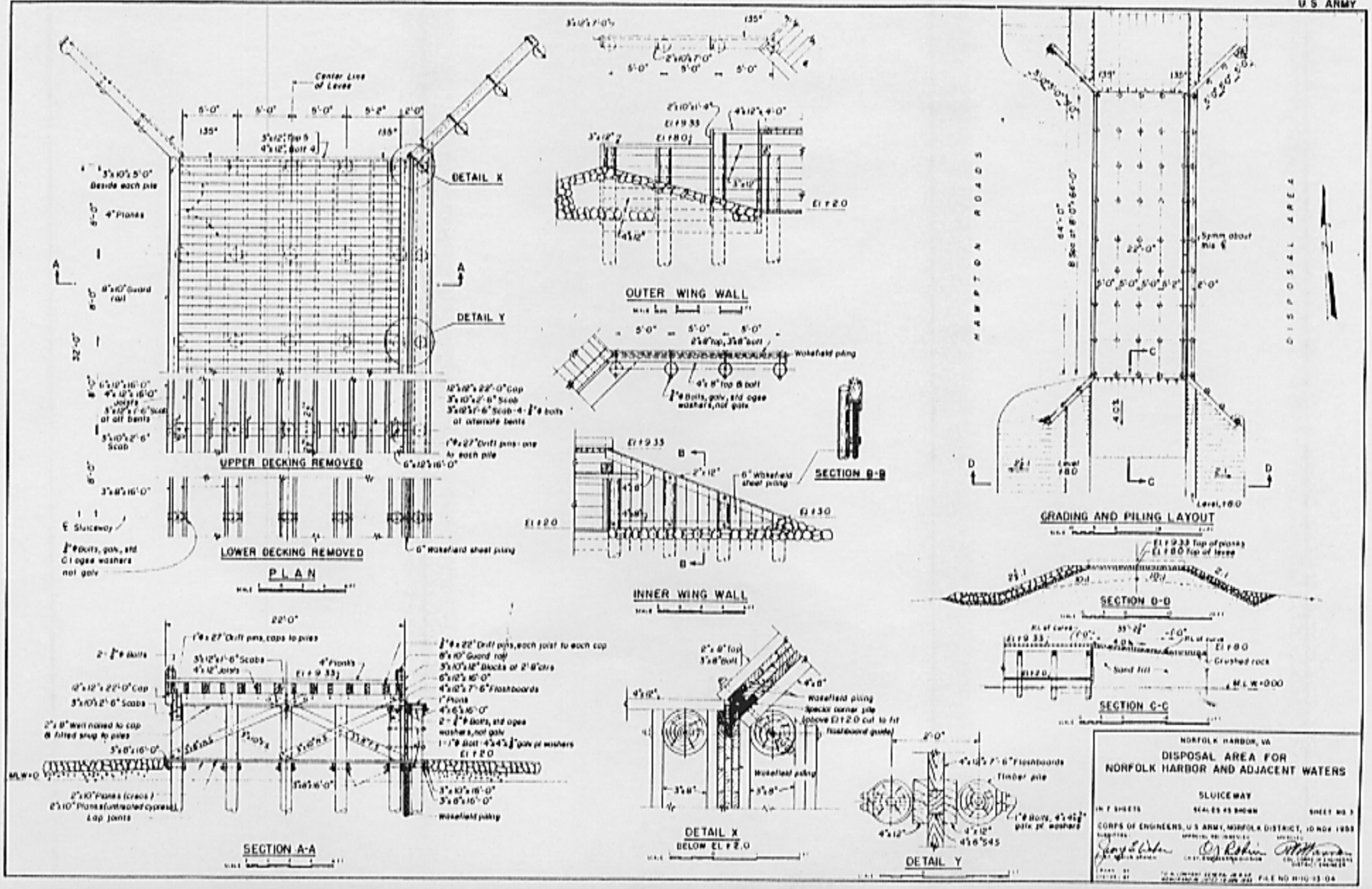
IN 7 SHEETS | SCALE IN FEET | SHEET NO. 6

CORPS OF ENGINEERS, U.S. ARMY, NORFOLK DISTRICT 10 NOV 1953

PLATE 6

CORPS OF ENGINEERS

U S ARMY



NORFOLK HARBOR, VA

DISPOSAL AREA FOR NORFOLK HARBOR AND ADJACENT WATERS

SLUICEWAY

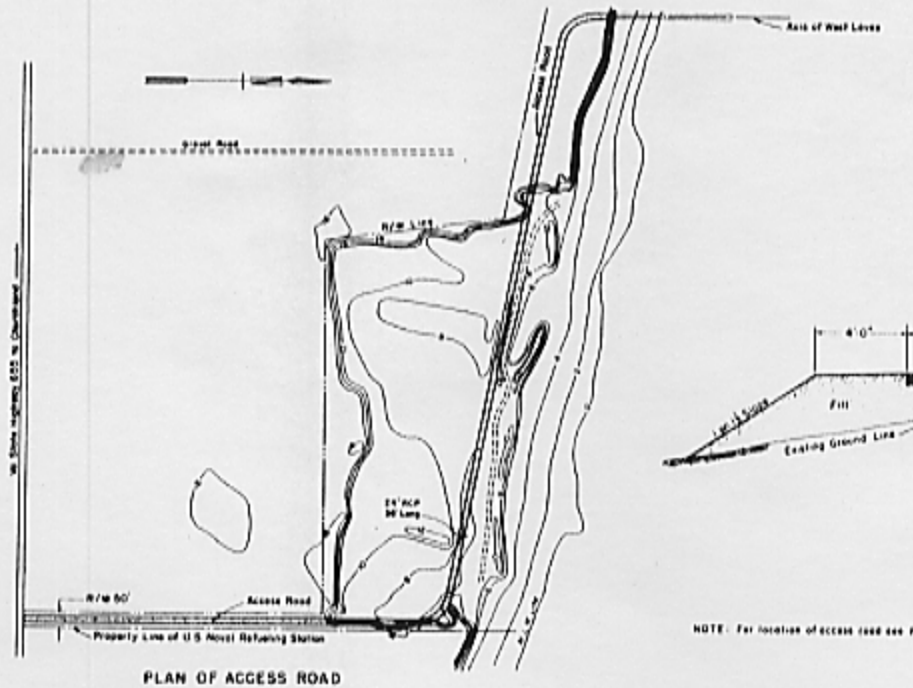
IN 7 SHEETS | SCALES AS SHOWN | SHEET NO 3

CORPS OF ENGINEERS, U S ARMY, NORFOLK DISTRICT, 10 NOV 1953

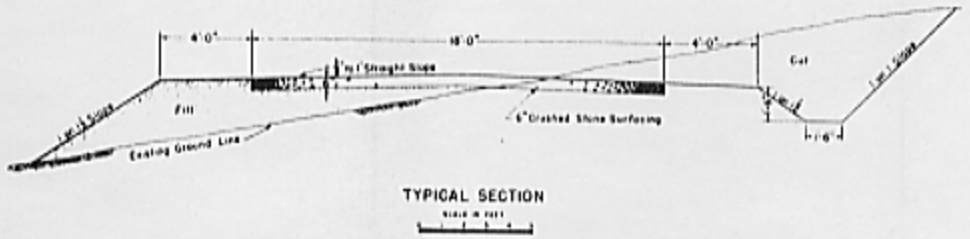
FILE NO NHO-13-04

CORPS OF ENGINEERS

U. S. ARMY

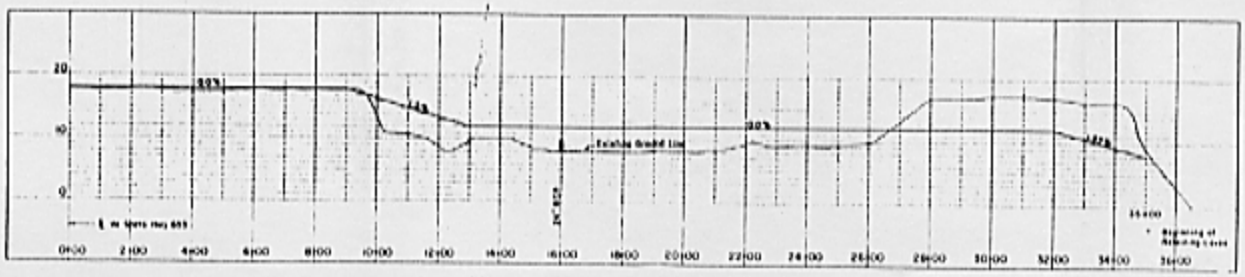


PLAN OF ACCESS ROAD



TYPICAL SECTION

NOTE: For location of access road see Plate 2



PROFILE ALONG CENTER LINE OF ACCESS ROAD

NORFOLK HARBOR, VA

DISPOSAL AREA FOR
NORFOLK HARBOR AND ADJACENT WATERS

ACCESS ROAD

IN 9 SHEETS SCALES AS SHOWN SHEET NO. 9

CORPS OF ENGINEERS, U.S. ARMY, NORFOLK DISTRICT, 10 NOV 1955

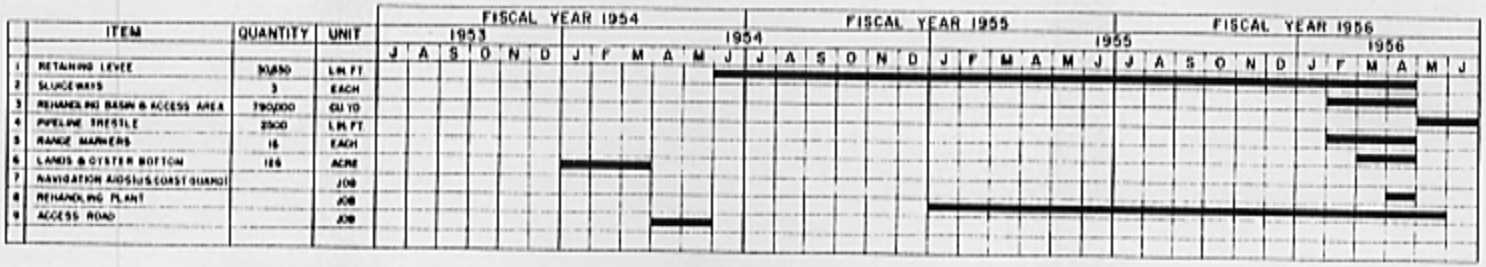
SUBMITTED APPROVED, RECOMMENDED APPROVED

FILE NO. H-13-84

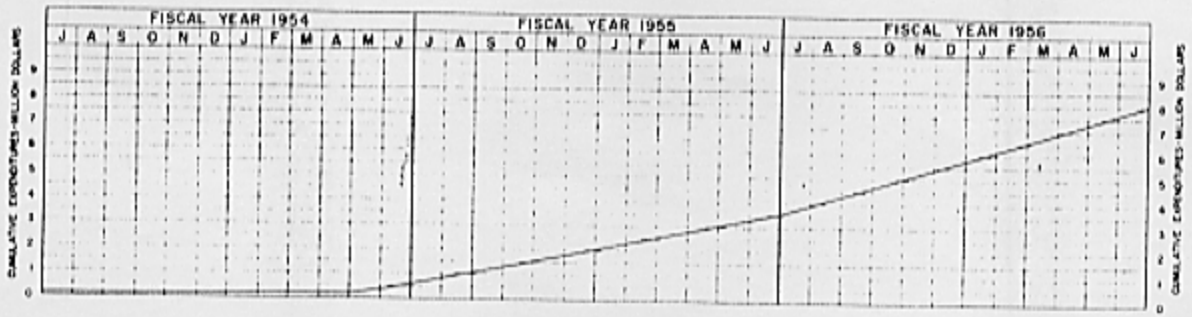
CORPS OF ENGINEERS

U.S. ARMY

	ITEM	QUANTITY	UNIT
1	RETAINING LEVEE	30,850	LIN FT
2	SLUICEWAYS	3	EACH
3	REHANDLING BASIN & ACCESS AREA	790,000	CU YD
4	PIPELINE TRESTLE	2900	LIN FT
5	RANGE MARKERS	16	EACH
6	LANDS & OYSTER BOTTOM	186	ACRE
7	NAVIGATION AIDS(U.S.COAST GUARD)		JOB
8	REHANDLING PLANT		JOB
9	ACCESS ROAD		JOB



CONSTRUCTION SCHEDULE



CUMULATIVE EXPENDITURES

NORFOLK HARBOR, VA.

DISPOSAL AREA FOR
NORFOLK HARBOR AND ADJACENT WATERS

CONSTRUCTION SCHEDULE
AND CUMULATIVE EXPENDITURES

CORPS OF ENGINEERS, U.S. ARMY, NORFOLK DISTRICT, 10 NOV 1953
SUBMITTED
APPROVED